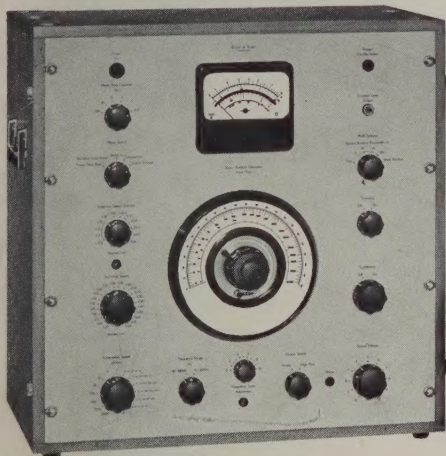


INSTRUCTIONS AND APPLICATIONS

Sine-Random Generator Type 1042



Designed for use in an integrated vibration test system in conjunction with the Vibration Meter Type 2502 or independently as a sinusoidal, narrow band random or wide band random signal generator. The frequency of the sinusoidal output and the centre frequency of the narrow band random output signal is tuneable manually, or automatically by a built-in motor. The Generator contains a compressor circuit which is fed from the Vibration Meter, making it possible to maintain the vibration level on the shaker table constant during a frequency sweep. Frequency range 5—10000 Hz.

Accelerometers
Acoustic Standing Wave Apparatus
Artificial Ears
Artificial Voices
Audio Frequency Response Tracers
Audio Frequency Spectrometers
Audio Frequency Vacuum-Tube Voltmeters
Automatic A.F. Response and Spectrum Recorders
Automatic Vibration-Exciter Control Generators
Band-Pass Filter Sets
Beat Frequency Oscillators
Complex Modulus Apparatus
Condenser Microphones
Deviation Bridges
Distortion Measuring Bridges
Frequency Analyzers
Frequency Measuring Bridges
Hearing Aid Test Apparatus
Heterodyne Voltmeters
Level Recorders
Megohmmeters
Microphone Accessories
Microphone Amplifiers
Microphone Calibration Apparatus
Mobile Laboratories
Noise Generators
Noise Limit Indicators
Pistonphones
Polar Diagram Recorders
Preamplifiers
Precision Sound Level Meters
Recording Paper
Strain Gage Apparatus and Accessories
Surface Roughness Meters
Variable Frequency Rejection Filters
VHF-Converters
Vibration Pick-ups
Vibration Pick-up Preamplifiers
Wide Range Vacuum Tube Voltmeters

BRÜEL & KJÆR

NÆRUM, DENMARK. Teleph.: 80 05 00. Cable: BRUKJA. Telex: 5316. COPENHAGEN





Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_10336

Sine-Random Generator

Type 1042

JUNE 1967

Contents

1. Introduction	5
2. Description	7
2.1. Narrow Band Noise Condition	7
2.2. Wide Band Noise	9
2.3. Sine-Wave	9
2.4. Output Voltmeter	9
2.5. Compressor Arrangement	9
2.6. Distortion of Output Signal	10
2.7. Presetting Vibration Level	11
2.8. Automatic Frequency Scan	11
2.9. Frequency Calibration	11
2.10. Constant Voltage Supply	11
2.11. Remote Control	11
2.12. Parallel Operation of Generators	12
3. Control Knobs, and Terminals	14
4. Operation	25
4.1. Connection to Mains Supply	25
4.2. Interconnections	26
4.3. Initial Setting of Controls	26
4.4. Calibration of Frequency Scale	27
4.5. Adjustment of Automatic Frequency Scanning Range	27
4.6. Uni-directional Frequency Scanning	28
4.7. Partial Blocking of Frequency Scale Range	28
4.8. Setting of Scanning Speed	29
4.9. Possibilities of Regulation	30
4.10. Setting Auto Cross-over Frequency	32
4.11. Setting Compressor Speed	32
4.12. Setting of MODE SELECTOR, METER TIME CONSTANT and METER INDICATION	34
4.13. Reading Vibration Level	34
4.14. Vibration Level Preset	34
4.15. Summary of Preparatory Operations	35
4.16. Final Check of the Set-up and Start of Test	37
5. Operation with Level Recorder	39
5.1. Possibilities	39

5.2. Synchronization with Level Recorder	39
1. Use of the six special scanning speeds	39
2. Use of the Motor Drive UM 1018	42
5.3. Monitoring Shaker Table Motion	44
5.4. Plotting System Frequency Response	45
5.5. Recording Specimen Vibration	47
5.6. Recording Two Quantities Simultaneously	48
6. Remote Control Facilities	49
6.1. Start and Stop of Automatic Frequency Scan	49
6.2. Forward and Reverse Frequency Scan	49
6.3. Stand by	50
6.4. Changing Scanning Speed	50
7. Master-Slave System	52
7.1. Principles	52
7.2. Interconnections	53
7.3. Setting Up	54
7.4. Adjusting Individual Vibrations (Level and Phase)	55
7.5. Command of the System	55
8. Programming System	56
8.1. Description	56
8.2. Interconnections	58
8.3. Modification to Generator	59
8.4. Modification to Vibration Meter	60
8.5. Combinations	60
8.6. Operation	62
9. Conversion Charts, Tables etc.	64
10. Specifications	68

1. Introduction

The Sine-Random Generator Type 1042 is designed to be used in integrated vibration test systems for controlling the shaker table movement. The generator can supply sine-wave signals, or narrow band noise signals (with various bandwidths) as well as a wide-band noise signal. It has a frequency range of 10 Hz–10 kHz and additionally a range 5 Hz–10 kHz. A regulation (compressor) arrangement designed to work in a closed servo loop offers programmed and selectable regulation speeds.

The compressor makes it possible to maintain, for example, constant acceleration, velocity or displacement level of the shaker table movement, in both sine-wave and narrow noise band conditions.

The generator incorporates a reversible motor drive, for continuously scanning the frequency scale. Several scanning speeds are available and some of them are made for synchronous operation with the Level Recorder Type 2305.

By means of a built-in vacuum tube voltmeter with selectable integration times the RMS level of the output signal, sine-wave or noise, can be measured.

The Sine-Random generator is intended to be used together with the Vibration Meter Type 2502 on which the various vibration levels can be read and via which the regulation signal for the compressor arrangement is supplied. Several of the Sine-Random Generator's functions can be remotely controlled. In cases where two or more vibration systems have to be operated in parallel, the Generators can be wired up in a "master-slave" arrangement.

With the Vibration Meter Type 2502 and auxiliary instruments Control Signal Selector Type 4410 and Vibration Programmer Type 4411 a variety of possibilities have been created for automatic programming of sweep-sine and sweep narrow band random vibration testing. The entire instrumentation entails controls from up to four accelerometers simultaneously on an average, highest or lowest basis, and a break up of the test frequency range into six continuously adjustable frequency sub-ranges with individual function control in each range. As test specimens become larger and more complex the vibration test engineer finds that the single accelerometer feedback control is inadequate. A multiple input test system in general has different mechanical impedances at the different input points, whereby differences in motion will occur. Fixture design aims at avoiding these differences but is seldom completely successful. Large differences in motion often occur from input point to input point, and a one-accelerometer control system results in overtesting or undertesting in important frequency ranges.

One way of reducing overtesting is to use as feedback signal an average of the vibration signals from the input points. This reduces the overtesting to a factor less than n , where n is the number of input points. Using for example

four accelerometers at four input points will reduce overtesting to less than 12 dB. Undertesting will only be slightly affected.

If a further reduction of overtesting is found necessary this can be done by switching circuits automatically selecting the largest of the signals from the measuring points. Overtesting is thereby reduced to zero. Undertesting is not remedied.

Undertesting due to different motion at input points can similarly be eliminated by selecting the smallest of the vibration signals for feedback. This procedure does not necessarily affect overtesting.

The instrumentation mentioned above has facilities for feedback control via the average, the highest or the lowest of up to four accelerometer signals using the average value of the signals as a basis for control.

As test specifications become more exacting with regard to excitation versus frequency characteristic, it is found desirable to have more possibilities of varying the slope of the characteristic over the frequency sweep. So far only one cross-over has been available, with cross over from constant displacement to constant acceleration etc., at a preselected frequency.

The B & K equipment mentioned gives five adjustable cross-over points, with a variety of functions to choose from in each frequency sub-range, including an external filter facility. Thus any excitation versus frequency characteristic can be obtained for sweep-sine and sweep narrow band random vibration tests.

2. Description

The basic principles of operation of the Sine-Random Generator are illustrated in the block diagram Fig. 2.1.

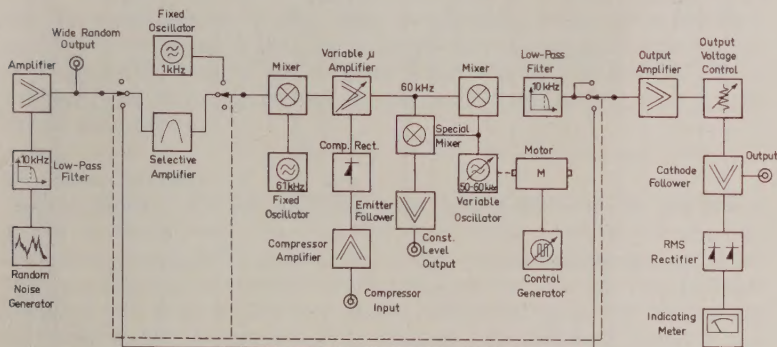


Fig. 2.1. Block diagram of Sine-Random Generator.

2.1. Narrow Band Noise Condition.

A noise generator supplies a wide band noise signal with constant spectrum density (white noise) and Gaussian amplitude distribution, via a low-pass filter with a limiting frequency of 10 kHz to an amplifier. In this amplifier the signal is filtered in a selective network having a fixed center frequency f_0 of 1,000 Hz. The 3 dB bandwidth of the selective amplifier can be chosen in four steps, viz. 3, 10, 30 and 100 Hz Fig. 2.2.

The selected noise band is then applied to a balanced modulator, where it is modulated by a carrier frequency of 61 kHz obtained from a fixed oscillator. The lower sideband (60 kHz) of the modulated signal is separated in a band-pass filter and via the 60 kHz output socket fed to an IF amplifier. This amplifier can simultaneously act as a regulation amplifier, as described later. After the lower side-band has been selected the signal is again modulated, this time by a carrier the frequency of which can be varied from 50–60 kHz. The lower side-band of the modulated signal is selected by a second low-pass filter having a limiting frequency of 12 kHz whereby it appears as a noise band, the bandwidth and center frequency of which are determined by the selective amplifier stage and the variable oscillator, respectively. The center frequency can be varied continuously in the frequency range 10 Hz–10 kHz and the actual

2. DESCRIPTION

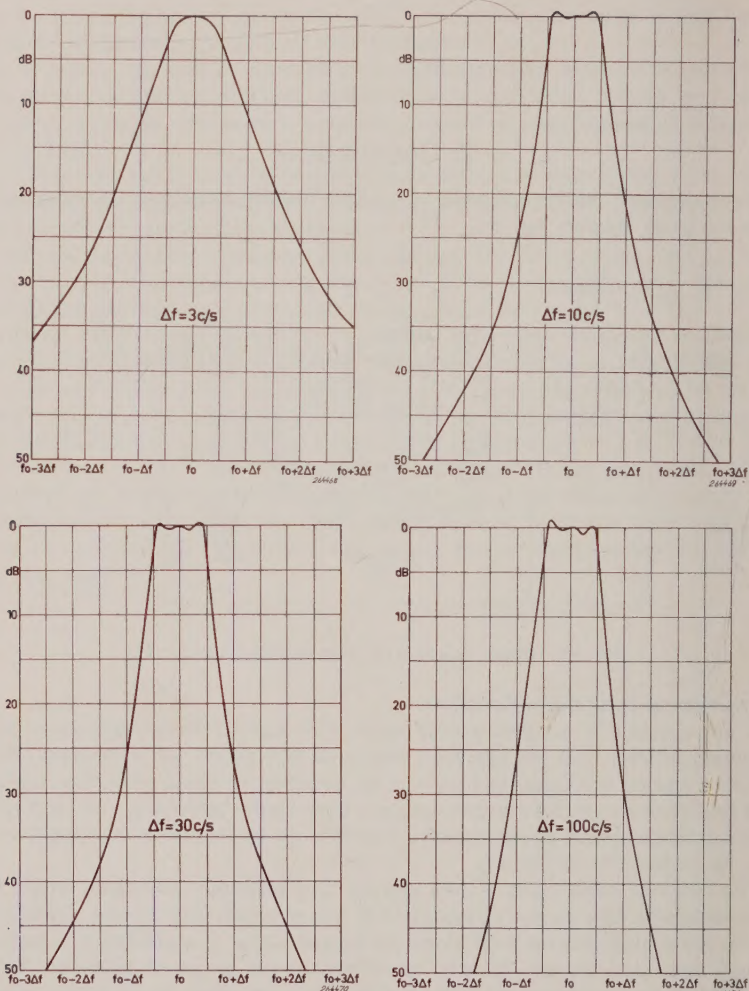


Fig. 2.2. Typical narrow band noise spectra available from the Generator.

frequency setting can be read on a circular logarithmic scale. A second range, 5–10,000 Hz, is obtained by changing the frequency of the fixed (61 kHz) oscillator by 5 Hz. The signal from the 2nd Low Pass Filter passes an LF amplifier stage before it is applied to an adjustable output level control immediately preceding the output amplifier. A cathode follower is used in the output amplifier ensuring a low output impedance.

2.2. Wide Band Noise.

Wide band noise in the range 5 Hz–10kHz is supplied by connecting the output of the first amplifier directly to the input of the third amplifier. The wide band noise is also accessible at a Wide Random Output socket at the rear panel independent of the chosen output spectrum of the generator. See block diagram.

2.3. Sine-Wave.

A sine-wave signal is supplied by the Sine-Random Generator when the 1 kHz oscillator, shown on the block diagram, is switched in, in place of the selective amplifier stage and the previous links. The signal on the output of the Sine-Random Generator will in this case be a sine-wave the frequency of which can be chosen in the range 10 Hz–10 kHz or 5–10,000 Hz by means of the variable oscillator. The frequency is read on the same scale as that used for the Narrow Band condition.

2.4. Output Voltmeter.

The RMS level of the output signal, noise or sine-wave, can be read on a built-in indicating meter. The indicating meter section contains an amplifier, a full wave (quasi) RMS signal rectifier and a moving coil instrument. Various time constants can be selected for the signal rectifier thus ensuring sufficient averaging time even for the very narrow noise band 3 Hz. The moving coil instrument is fully protected against overload. The indicating meter is also utilized during frequency calibration of the Sine-Random Generator.

2.5. Compressor Arrangement.

The output signal level from the Sine-Random Generator can be automatically regulated by means of a built-in regulation (compressor) arrangement. By utilizing this arrangement in a closed servo loop levels, such as acceleration, velocity etc., can automatically be kept constant on the shaker table. The compressor arrangement includes a compressor amplifier, an average type full wave signal rectifier and a regulation amplifier. This regulation amplifier is formed by two of the stages in the IF amplifier, which are designed as variable- μ amplifiers. The gain of the two stages is controlled by a DC voltage obtained from the regulation signal applied to the compressor input terminal. An average type rectifier is used for signal rectification to ensure equal regulation time constants for increasing and decreasing signal levels.*)

The compressor speed (regulation time constant) can be selected manually in eight steps, covering the range 1 to 3000 dB/sec., or can be adjusted automatically as a function of frequency according to six different programmes. The compressor speed can also be controlled by the cross-over switch and the circuit is wired so that the speed is 10 dB/sec below cross-over and

*) See also Brüel & Kjør Technical Review No. 4, 1962, P. E. Møller Petersen, "Problems in Feed Back Control of Narrow Band Random Noise".

100 dB/sec above. Should it be desired to use other compressor speeds, they may be obtained by rewiring the compressor speed circuit. However it is only possible to obtain speeds that are lower below cross-over than they are above, the lowest speed being 10 dB/sec.

A warning lamp indicates with a red light that the compressor is operating and that the setting of the control knobs with red spots should not be altered. The reason is that a change of the position of the knobs concerned can result in violent changes in the vibration level, whereby the test specimen or the vibration system itself may be damaged.

When the compressor arrangement is switched into operation the gain of the 2nd amplifier is simultaneously increased by approximately 10 dB. The amount of compression can be continuously monitored during operation. A position on the METER SWITCH denoted "Compression" connects the meter to the compressor circuit and a scale on the meter indicates the amount of compression in the range 0-80 dB.

2.6. Distortion of Output Signal.

In Fig. 2.3 are shown some distortion curves as a function of frequency for different compressor speeds. It can be seen that a compressor speed as slow as possible should be chosen in order to avoid heavy distortion for low frequencies. It is also seen that least distortion occurs when the amount of

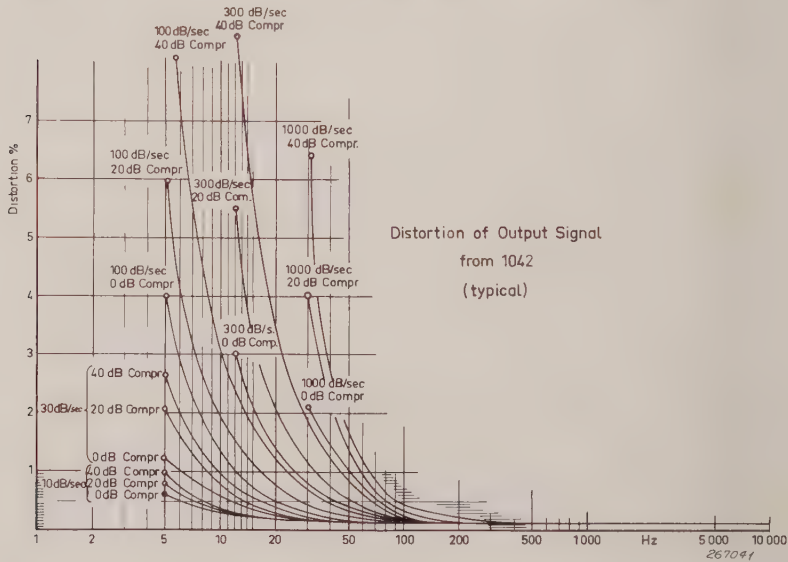


Fig. 2.3. Some distortion curves as a function of frequency for different compressor speeds.

compression is 0 dB. This should be kept in mind when the generator is set up to test.

2.7. Presetting Vibration Level.

By feeding the Generator output voltage to the Vibration Meter as if it was a vibration signal the whole vibration test system can be set up for the required vibration level without feeding any signal to the power amplifier and shaker. A minimum of pre-test vibration is thereby applied to the test specimen.

2.8. Automatic Frequency Scan.

The frequency range can be continuously scanned with various speeds by a built-in synchronous motor which can be reversed electrically. A unijunction transistor oscillator supplies the power for the motor. By altering the frequency of the oscillator the motor speed can be changed in six coarse steps, covering the range 0.3 to 100 degrees/min. Within each of the six steps the speed can be fine adjusted in 22 steps. Using both controls provided, there are 130 possible scanning speeds from 0.3 to 300 degrees/min. Additionally there are six other scanning speeds suitable for achieving synchronism with the frequency-calibrated-paper transport on the Brüel & Kjær Level Recorder Type 2305.

2.9. Frequency Calibration.

The Generator is frequency calibrated by checking two points on the frequency scale against a well defined frequency. The reference frequency is that of the mains supply which is compared first to the fundamental and then to the fifth harmonic of the Generator signal. The fifth harmonic of the Generator signal is obtained by feeding the Generator output signal to the indicating meter via a network causing heavy non-linear distortion. By also applying a part of the mains supply voltage to the indicating meter, a beat between the two signals will result. When the Generator is set to the fundamental of the mains supply frequency a zero beat is obtained for correct calibration. The fine calibration can be made in a similar way to one fifth of the mains frequency. Any necessary adjustment of the Generator frequency is made by a separate control, changing the frequency of the variable oscillator.

2.10. Constant Voltage Supply.

By feeding the voltage from the 60 kHz output socket to a special mixer together with the signal from the variable oscillator (50–60 kHz) a constant output level of 1 V RMS following the frequency sweep of the generator is obtained. The type of voltage can be either narrow band noise with a bandwidth corresponding with that of the setting of the generator or pure sine-wave. A wide band noise signal is not available from the Constant Voltage Supply.

2.11. Remote Control.

Various functions of the Sine-Random Generator can be remotely controlled, they are:

1. Start and Stop of automatic frequency scan. In case the Brüel & Kjær Level Recorder Type 2305 is used together with the Generator the start and stop of the Recorder paper drive can be synchronized with the remote start and stop of the frequency scan.
2. Change of frequency scan from forward to reverse and vice-versa.
3. Stand by, which is a condition of the Generator where the output voltage is suppressed by the compressor.
4. Change of scanning speed.

About the wiring for the various remote control facilities the operator is referred to part "Remote Control Facilities" in this book.

2.12. Parallel Operation of Generators.

Two or more complete vibration systems can be driven in parallel in a so-called "master-slave" arrangement, which means that one of the paralleled Sine-Random Generators, the "master", governs the others, Fig. 2.4a. The basic principle in the parallel arrangement is that the signals from both the fixed and the variable oscillator in the "master" are used not only for the "master" itself but for the "slaves" as well, Fig. 2.4b. This means that the shakers

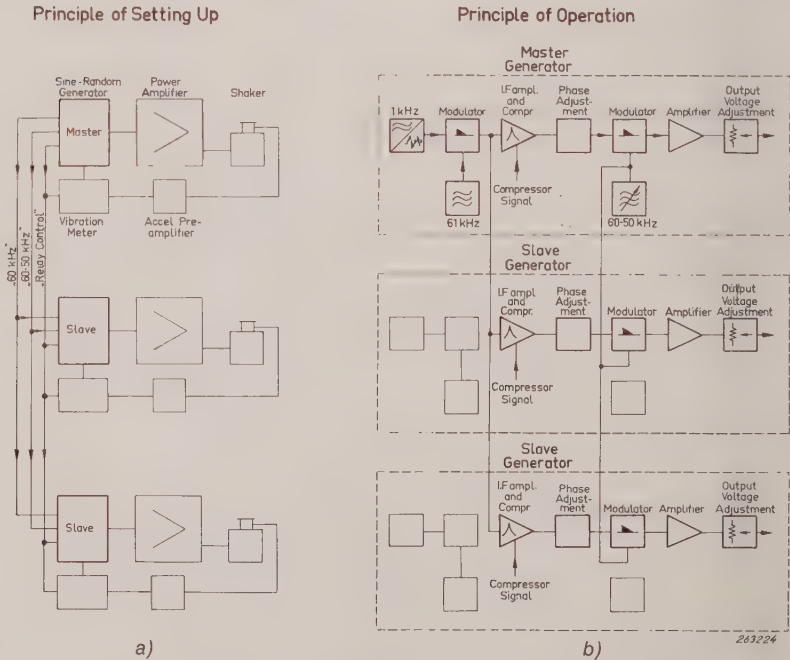


Fig. 2.4. "Master slave" arrangement of 3 Sine-Random Generators.

driven in this parallel arrangement are vibrating with the same frequency but have individual compressor systems. The phase difference in the movement of the different shaker tables can be adjusted on the individual Generators. Also the programmed compressor speed setting, working as a function of frequency, can be governed from the "master", so that the compressors of the "master" and the "slaves" regulate with equal speeds, but at individual vibration levels. Full details about the wiring and lining up is given in part "Master-Slave System" in this book.

3. Control Knobs, and Terminals

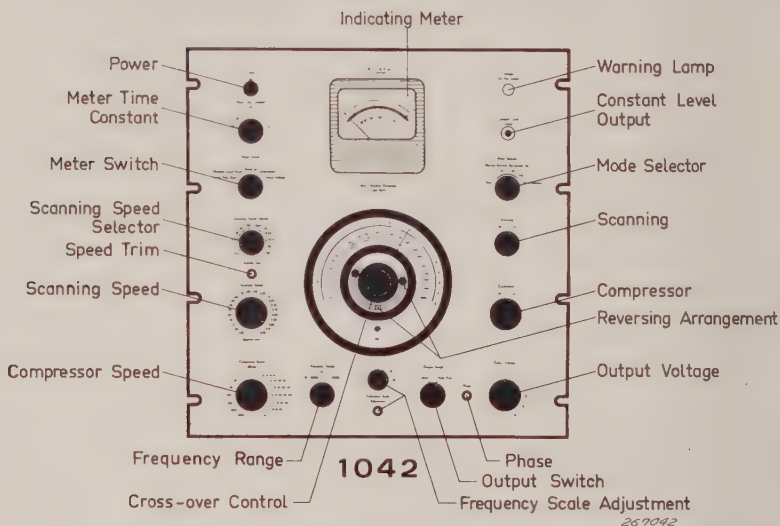


Fig. 3.1. Sine-Random Generator front panel.

Front Panel (refer to Fig. 3.1).

POWER ON:

To switch the power on and off for the complete apparatus. When switched on the indicating meter and frequency scales are illuminated.

METER TIME CONSTANT: For alteration of meter rectifier averaging time. The selectable values "0.3", "1", "3", "10", "30", and "100" sec. indicate the time it takes the meter pointer to fall, when disconnecting the signal, to 1/3 of the original deflection.

METER SWITCH:

"Power Frequency Beat". In this position the complete Generator can be frequency calibrated against the mains supply frequency. (Covers both FREQUENCY RANGE control positions). **"Vibration Level Preset".** By feeding the Generator output voltage to the Vibration Meter Type 2502 as if it was a vibration signal, the whole vibration test

system can be set up for the required vibration level without feeding any signal to the power amplifier and shaker.

"Stand by". The output signal of the Generator is suppressed by the compressor circuit by more than 70 dB relative to full drive. The speed at which the signal is suppressed and rises again with COMPRESSOR set to "Off" is in the order of:

Decay time (90–10 %), 150 msec.

Rise time (10–90 %), 30 msec.

When the COMPRESSOR is in "On" position, the rise time depends on the COMPRESSOR SPEED setting, i.e. a high speed gives a short rise time. The decay time, however, is independent of COMPRESSOR SPEED setting and has the value given above.

"Compression". The meter is connected to the compressor circuit and a scale on the meter indicates the amount of compression in the range 0–80 dB.

"Output Voltage". RMS level of signal on socket OUTPUT (rear panel) is read. Full deflection indicates full RMS drive of the output amplifier.

SCANNING SPEED SELECTOR:

" $\times 0.3$ ", " $\times 1$ ", " $\times 3$ ", " $\times 10$ ", " $\times 30$ " and " $\times 100$ " are factors by which the degrees/min. value indicated on the SCANNING SPEED control should be multiplied. The result gives the actual scanning speed of the frequency scale pointer in degrees/min. The six values on the right side of the control indicate the speeds available when the Brüel & Kjær Level Recorder Type 2305 is used in combination with the Sine-Random Generator. The correlation between the six different values and the paper speed setting on the Level Recorder is shown in the table below.

"Scanning Speed selector" position degrees/min	0.864	2.59	8.64	25.9	86.4	259
Level Recorder Paper Speed mm/sec	0.01	0.03	0.1	0.3	1	3
Pulse interval for Sine-Random Generator drivemotor. Milliseconds	50.00	16.67	5.000	55.54	16.66	5.554

The motor supply frequency can be fine adjusted by the screwdriver control located below the SCANNING SPEED SELECTOR.

Note: When set to one of the scanning speeds tabulated above, the SCANNING SPEED control below the SCANNING SPEED SELECTOR is automatically switched out of circuit.

The exact frequency (or pulse interval) of the motor power supply can be monitored on, for example, an electronic counter. The signal is available on the rear of the Generator at the socket SWEEP CONTROL B between pin 4 and chassis.

SCANNING SPEED:

For setting, in combination with SCANNING SPEED SELECTOR, the speed for the automatic frequency scanning device. To obtain the actual scanning speed the degrees/min. value indicated by SCANNING SPEED has to be multiplied with the factor indicated by the SCANNING SPEED SELECTOR.

The SCANNING SPEED control is not in operation when the SCANNING SPEED SELECTOR is set to one of the six values printed to the right of the control knob.

FREQUENCY RANGE ADJUSTMENT:

The frequency range which should be scanned by the internal motor can be preset by two finger screws. When the scale pointer reaches the preset points on the scale the motor reverses automatically.

COMPRESSOR SPEED:

For setting the regulation speed of the compressor arrangement. In operation only when the knob COMPRESSOR is set to position "On".

"1", "3", "10" "3000" indicate fixed regulation speeds in dB/sec. which do not change as a function of frequency.

"10-30-30-30-30", "10-30-100-100-100"
"10-10-10-30-100" refer to different programmed changes in regulation speed as a function of frequency. The compressor speed is altered step-wise to the various values at the change-over frequencies given in the table below:

Change-over frequencies*)	30	100	300	1000	Hz
Compressor speed positions	10-30-	30-	30-	30	dB/sec
	10-30-100-	100-	100		»
	10-30-100-300-	300			»
	10-30-100-300-1000				»
	10-10-	30-100-	300		»
	10-10-	10-	30-	100	»

"A-G". The compressor speed is controlled by the cross-over switch. The speed is 10 dB/sec below cross-over and 100 dB/sec above (may be altered by rewiring the compressor speed circuit).

FREQUENCY RANGE: **"10-10000 Hz".** The frequency is read on the middle scale.

"5-10000 Hz". The frequency is read on the inner scale. Above 200 Hz the frequency scales nearly coincide so that the middle scale also may be used in this frequency range.

**FREQUENCY SCALE
ADJUSTMENT:**

For frequency calibration of the Generator, changes the frequency of the variable oscillator. The screw-driver operated control is for coarse adjustment in case the range of the fine adjustment control is not sufficient.

OUTPUT SWITCH:

"Linear". The amplitude-frequency characteristic of the generator is flat, independent of frequency.

"High Pass". The lower part of the frequency range is attenuated by a high-pass filter. The limiting frequency is 15 Hz and the maximum slope is 6 dB/octave below this frequency.

PHASE:

In, for example, a "master slave" arrangement, the phase between the individual Generator output signals can be adjusted. The phase shifting range covered by the screw-driver operable control is approximately 150°.

*) In the frequency range 5-10000 Hz the change-over frequencies are 5 Hz lower than stated in the table.

- OUTPUT VOLTAGE:** Continuously variable logarithmic potentiometer, located at the input of the output amplifier.
When OUTPUT VOLTAGE is turned fully counter-clockwise the reset circuit terminals are short-circuited and the Warning Lamp switches off if it is alight.
- SCALES:**
- Outer Scale:** Linear in degrees angle for determining the scanning speed in degrees/min.
- Middle Scale:** Logarithmic in Hz. The scale pointer indicates either the frequency of the output sine-wave or the center frequency of the narrow band noise output signal.
- Inner Scale:** Obtained by subtracting 5 Hz from the middle scale, not logarithmic. The scale pointer indicates the same as above.
- COMPRESSOR:**
- "Off".** The regulation (compressor) arrangement is disconnected.
- "On".** The compressor arrangement is switched in circuit. Simultaneously, the gain of the IF amplifier section is increased approximately 10 dB, ensuring a larger regulation range.
- SCANNING:**
- "Off".** The automatic frequency scanning drive is stopped instantaneously.
- "On".** The automatic frequency scanning drive is started instantaneously.
- MODE SELECTOR:**
- "Sine".** In this mode the Generator supplies a sine-wave signal at the OUTPUT socket which is accessible at the rear panel.
- "Narrow Random".** The figures "3", "10", "30" and "100" indicate the 3 dB bandwidth in Hz of the noise bands available at the OUTPUT socket. The shape of the noise bands are illustrated in Fig. 2.2.
- "Wide Random".** A noise signal with uniform spectrum density (white noise) in the frequency range 5 Hz–10 kHz and with Gaussian distribution is present at the OUTPUT socket. In this case the compressor arrangement is not incorporated.
- CONSTANT LEVEL OUTPUT:**
- A voltage of 1 V RMS following the frequency sweep is available.

The voltage type corresponds to the setting of MODE SELECTOR. *Exception:* No useful voltage with MODE SELECTOR set to "Wide Random".

The voltage may for example synchronize a stroboscope.

Load impedance should be greater than $10\text{ k}\Omega/3\text{ nF}$.

DANGER DO NOT SWITCH:

Warning lamp. Indicates with a red light that the compressor is operating and that the setting of the following control knobs with red spots *should not be altered:*

MODE SELECTOR, COMPRESSOR, OUTPUT SWITCH, FREQUENCY RANGE and COMPRESSOR SPEED.

If the position of these knobs is altered when the lamp is alight violent changes in the vibration level can occur, which may damage the test specimen or the vibration system itself.

Identical warning lamps may be built-in in other instruments in the complete vibration system. By making adequate connections from the Sine-Random Generator to these instruments, their warning lamps will be controlled from the warning lamp control circuit in the Sine-Random Generator.

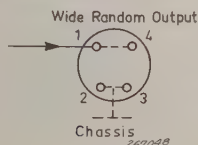
INDICATING METER:

Measures the RMS signal level at the OUTPUT socket or the compression in dB. Also used during frequency calibration of the Generator. The various functions are selected by the METER SWITCH.

Rear Panel (refer to Fig. 3.2).

Note: The wiring shown in the following socket diagrams is internal. All sockets are viewed externally. Where a shorting link is shown (dashed line) this is soldered onto the inside of the socket. Such links may have to be removed when wiring up one of the special facilities. For standard procedures, however, they must be in place.

WIDE RANDOM OUTPUT:



Plug: Cannon WK-4-21C.

Wide band noise (5 Hz – 10 kHz) with an RMS level of approximately 5 V.

Load impedance may be $25\text{ k}\Omega$ or higher. Maximum capacitive load 3 nF.

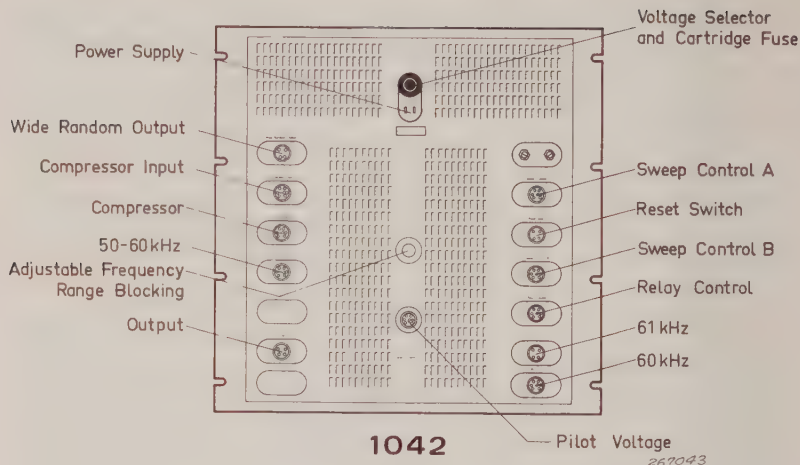
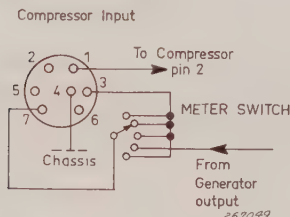


Fig. 3.2. Sine-Random Generator rear panel.

COMPRESSOR INPUT:

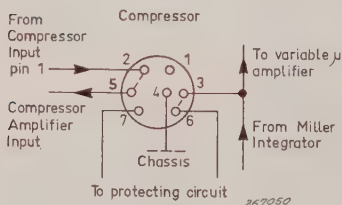


Plug: Cannon WK-A7-21C.

Pins 1 and 4 regulation (compressor) signal input. Signal level should be between 0.5 and 1 V approx.

Pins 3 and 7. Feeds the generator output to the Vibration Meter Type 2502 when METER SWITCH (1042) is set to "Vibration Level Preset" and are short-circuited in the other positions.

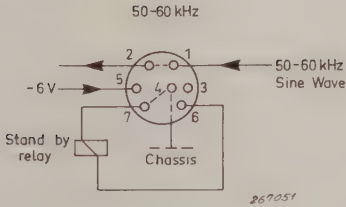
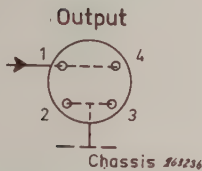
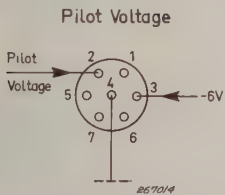
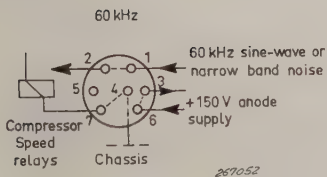
COMPRESSOR:



Plug: Cannon WK-A7-21C.

Pins 2 and 5. If it is desired to give the compressor circuit a particular frequency weighting, a network with the required shaping characteristic can be inserted between 2 and 5. The standard interconnection between the two pins has to be removed.

Pins 6 and 7. Intended for connection of a system protecting circuit, which switches off the shaker power amplifier if sudden changes in the feed back voltage occur.

50-60 kHz:**OUTPUT:****PILOT VOLTAGE:****60 kHz:**

Pins 3 and 6. The short circuit has to be broken when a DC compressor signal is used, for example from the Control Signal Selector Type 4410. DC compressor signal to pin 3.

Plug: Cannon WK-A7-21C.

Pins 1 and 2, 4 and 7. To be utilized in a "master-slave" arrangement. Further instruction is given in part "Master-Slave System".

Pins 5 and 6. For remote operation of "Stand by". By interconnection of pins 5 and 6 the Generator is set to "Stand by".

Plug: Cannon WK-4-21C.

Generator output terminal. Indicating meter measures at this terminal when METER SWITCH is in position "Output Voltage".

Plug: Cannon WK-A7-21C.

Pin 2. Pilot voltage for the Vibration Programmer Type 4411 governed by the angular position of the frequency scale pointer.

Pin 3. -6 V DC.

Pin 4. Ground.

Plug: Cannon WK-A7-21C.

To be utilized in a "master-slave" arrangement, further instruction is given in part "Master-Slave System".

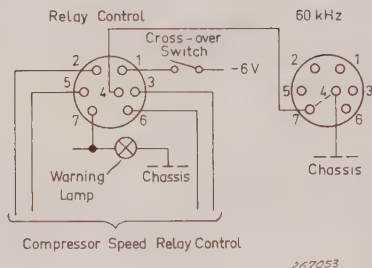
61 kHz:



Plug: Cannon WK-4-21C.

The 61 kHz signal from the fixed oscillator is accessible on this socket.

RELAY CONTROL:



Plug: Cannon WK-A7-21C.

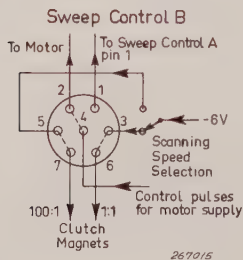
Pin 1. For governing the cross-over relay circuit in the Vibration Meter Type 2502. 6 V is present on pin 1 when the cross-over switch is closed.

Pins 1 to 7. To be utilized in a "master-slave" arrangement. Further instruction is given in part "Master-Slave System".

Pins 2, 3, and 5. Additionally used to switch in and out three stabilization networks in the Vibration Meter Type 2502.

Pin 7. For operation of "Danger do not Switch" lamps remotely controlled by the generator. -6 V is present when the compressor is operating.

SWEEP CONTROL B:



Plug: Cannon WK-A7-21C.

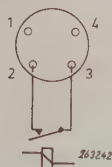
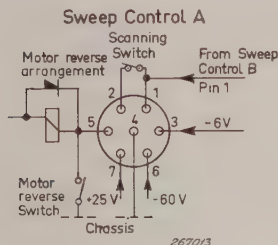
Pins 2 and 4. Intended for remote control of motor start and stop. Further instruction is given in part "Remote Control Facilities". Between 4 and chassis, the control signal for the motor can be monitored.

Pins 5 and 7, 3 and 6. For remote control of a gear shift arrangement in the scanning speed system.

Pin 1. When using Motor Drive UM 1018 pins 1 and 2 are short-circuited by a plug whereby the motor drive signals are fed to UM 1018.

RESET SWITCH:

Reset Switch

**SWEEP CONTROL A:****FUSE HOLDER AND
MAINS VOLTAGE
SELECTOR:**

Concerning the fuse see below. By the mains Voltage Selector, the Generator can be set to operate at 100, 115, 127, 150, 220 and 240 volts mains supply, 50–400 Hz.

**ADJUSTABLE
FREQUENCY RANGE
BLOCKING:**

Three cam discs are mounted on the frequency scale pointer shaft. These operate a pair of contacts, which in turn control the Stand-by circuit of the Generator. One cam disc which is permanently fixed on the shaft, sets the Generator to stand by when the frequency scale pointer is outside the frequency scale graduation. The two other discs are adjustable inside the frequency scale graduation, so that any initial or final part of the frequency range can be blocked, i.e. the Generator will be in stand by condition outside the preset ranges. Detailed instruction is given in "Operation".

Plug: Cannon WK-4-21C.

Relay contact connection for resetting the shaker power amplifier when this has been disconnected by a system protecting circuit. The relay is governed by the OUTPUT VOLTAGE control and the contact pair will close when OUTPUT VOLTAGE control is turned fully counter-clockwise.

Plug: Cannon WK-A7-21C.

Pins 1 and 2: For remote operation of the paper drive start and stop of a Brüel & Kjær Level Recorder Type 2305. When SCANNING is set to position "On" the contact between pins 1 and 2 opens.

Pins 4 and 5. For remotely reversing the scanning motor.

Note: The arm of the motor reverse switch should be unscrewed during remote control.

Pins 1, 3, 4, 5, 6 and 7: For remote operation of the Motor Drive UM 1018.

FUSES:

Main Fuse 1.6 A medium lag. In circuit with the primary of the mains transformer. The fuse holder is combined with the MAINS VOLTAGE SELECTOR at the rear of the apparatus. Two spare fuses, accessible after removing the rear plate, are placed in a holder on the upper chassis.

6 Volts DC Supply. 2.5 A normal. Protects the 6 V DC supply circuit. The fuse is a "soldering-in" Type. It is accessible from the rear of apparatus after the rear plate has been removed, and is located on the vertical plate to the right of the capacitor unit.

4. Operation

In the following the setting up and adjustment of vibration systems comprising the Accelerometer Preamplifier Type 2622, Vibration Meter Type 2502, and the Sine-Random Generator Type 1042 are outlined. For operation of the power amplifier and the vibration exciter refer to the respective manuals. More complex programming systems are described in Chapter 8.

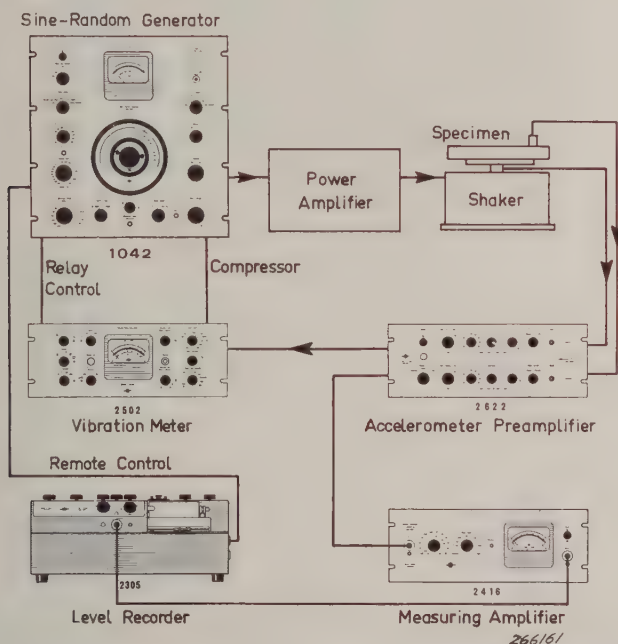


Fig. 4.1. Vibration system set-up with Accelerometer Preamplifier Type 2622, Vibration Meter Type 2502 and Sine-Random Generator Type 1042.

4.1. Connection to Mains Supply.

Before connecting the Preamplifier, Vibration Meter and Generator to the mains, ensure that the voltage selector, located at the rear, is adjusted to the

correct supply voltage. To readjust:

1. Remove fuse by turning centerpiece of voltage selector one quarter anti-clockwise.
2. Turn by a coin the center ring of the selector so that the white mark points to the desired voltage.
3. Replace fuse.

4.2. Interconnections.

In Fig 4.1 is shown the cable connections for the Preamplifier, Vibration Meter and Sine-Random Generator etc., and Table 4.1 indicates how the necessary interconnections can be made. The numbers in the circles refer to the table in section 8.2 giving the connection of the cables in the Programming System. The upper half of the circle indicates the type of cable and the lower half indicates the connection to be made.

Table 4.1.

	Inter- con- nect	Accelerometer Preamplifier Type 2622	Inter- con- nect	Vibration Meter Type 2502	Inter- con- nect	Sine- Random Generator Type 1042	Inter- con- nect	Power Amplifier
Control Accelerometer	↔	Input A		Relay Control	⊙ St. 6 ↔	Relay Control		
Monitor Accelerometer on Specimen	↔	Input B		Control Signal Output	⊙ St. 11 ↔	Com- pressor Input		
		Output A	⊙ E 7 ↔	Acceler- ation Input		Output	↔	Input
For ex- ample a CRO	↔	Output B						

Channels A and B of the Preamplifier may be interchanged as they are identical.

4.3. Initial Setting of Controls.

1. Sine-Random Generator:
 - a. Turn OUTPUT VOLTAGE completely anti-clockwise, a small click should be heard.
 - b. Set SCANNING to "Off".
 - c. Switch POWER to "On".

2. Vibration Meter:
 - a. Set METER TIME CONSTANT to "0.3".
3. Accelerometer Preamplifier:
 - a. Switch POWER to "On".
 - b. Set the SENSITIVITY knobs to the sensitivity of the accelerometer to be used.
 - c. Set the LOWER FREQUENCY LIMIT control to the highest acceptable value.

Note: If a preamplifier other than Type 2622 is used, it must incorporate sharp cut-off filters to attenuate frequencies outside the range of the 1042, and also its power supplies must be scrupulously stabilized. There should be provision for rationalizing its output scaling to 10 mV/g.

4.4. Calibration of Frequency Scale.

After the Generator POWER has been switched "On" for a few minutes, frequency calibration can be made.

1. Set control knobs as given below. Controls not mentioned can remain in any position.

METER TIME CONSTANT	to "0.3"
METER SWITCH	to "Power Freq. Beat"
FREQUENCY RANGE	to "10-10000"
COMPRESSOR	to "Off"
SCANNING	to "Off"
MODE SELECTOR	to "Sine"

Frequency scale pointer to frequency of the mains.

2. Turn FREQUENCY SCALE ADJUSTMENT until a beat shows up on the indicating meter. Fine adjust by same knob until beat ceases. In case the range covered by the control is insufficient, use also the coarse adjustment control (screwdriver operated).

Note: The meter pointer swing for a slow fluctuation may be in the order of 8 dB peak to peak.

3. Thereafter set frequency scale pointer to 1/5 of mains frequency.
4. Fine adjust again by FREQUENCY SCALE ADJUSTMENT control to obtain zero beat.

Note: The meter pointer swing for a slow fluctuation will now be in the order of 1 dB peak to peak.

Note: It is not necessary to disconnect the generator output from the power amplifier, as there is no output when the METER SWITCH is set to "Power Frequency Beat".

4.5. Adjustment of Automatic Frequency Scanning Range.

1. Choose the correct setting of FREQUENCY RANGE.
2. Loosen the finger screws Sa and Sb on the slotted plate, Fig. 4.2.
3. Turn frequency scale to the lower frequency limit of the range within which it is desired to scan.



Fig. 4.2. Frequency Scale with automatic frequency scanning adjustment screws.

4. Set reverse-switch arm, located underneath guide slot, to its left hand position.
5. Move screw Sa counter-clockwise in the circular guide slot so far that the reverse switch just switches. Fasten screw Sa in this position.
6. Turn frequency scale pointer clockwise to the point of the higher frequency limit of scanning range.
7. Move screw Sb clockwise so far that the reverse switch just switches. Fasten screw Sb in this position.

The selected frequency range will now be scanned automatically in a forward and reverse direction if the SCANNING switch is set to "On".

4.6. Uni-directional Frequency Scanning.

Normally the automatic frequency scanning is performed as a series of forward/reverse scans and the adjustment of the scanning range is made as described in section 4.5. However, in some cases it may be advantageous to scan the frequency range a number of times in one direction only. This is made possible if the reverse switch arm is removed. The arm can be easily unscrewed from the associated micro-switch by means of a screwdriver, see Fig. 4.2. If the arm is pushed to the right before it is unscrewed a continuous "forward" scanning of the frequency range is obtained, while pushing the arm to the left results in continuous reverse scanning. When used for continuous uni-directional scanning it is often necessary to partially block the upper and/or lower part of the frequency scale range. The manipulations necessary to carry out the blocking are described below.

4.7. Partial Blocking of Frequency Scale Range.

The initial and/or the final part of the Frequency Scale can be blocked out by two adjustable cam discs. This facility can be utilized when the Frequency

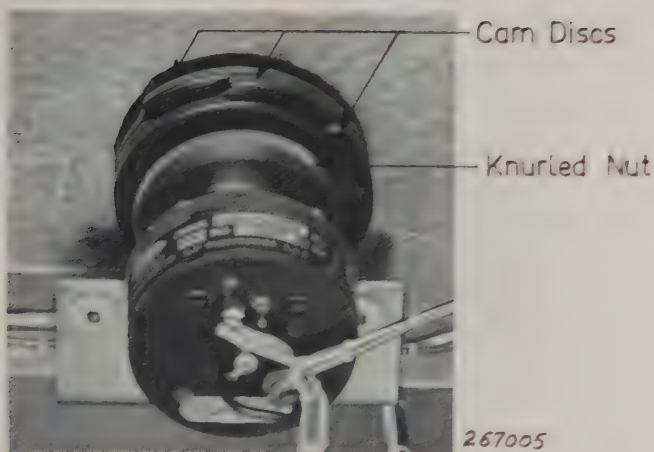


Fig. 4.3. Cam disc arrangement for blocking of Generator output signal

Scale pointer has to perform unidirectional scanning. Any initial part 10 Hz up to 400 Hz of the scale can be blocked and/or any final part 10 000 Hz down to 300 Hz.

The blocking range is adjusted as follows:

1. Remove rear plate of Generator.
2. Loosen knurled lock-nut (Fig. 4.3) sufficiently for the outer and inner cam discs to be moved in relation to the one in the middle.
Note: If it is not possible to hold the Frequency Scale pointer shaft in a fixed position by holding the Frequency Scale adjustment knob (front plate) the automatic scanning can be switched on and set to lowest speed.
3. Set for example outer cam disc for initial Scale part blocking so that the Generator "Stand By" is released at the desired frequency. The point of release can be observed on the indicating meter when METER SWITCH is set to "Compression" and COMPRESSOR control to "Off". When released the meter pointer will suddenly deflect).
4. Set the inner cam disc for final Scale part blocking so that Generator is switched to "Stand By" at the desired frequency (Observed by a sudden decrease in meter pointer deflection).
5. Tighten the knurled lock-nut.
6. Replace rear plate.

4.8. Setting of Scanning Speed.

If a certain frequency range f_1 to f_2 and back to f_1 has to be scanned in t minutes use the procedure:

1. Determine from the Generator's Frequency Scale the number of degrees d the range f_1 to f_2 covers.
2. Find scanning speed S in degrees/min. from:

$$S = \frac{2 \times d}{t} \text{ degrees/min.}$$

3. From the curves in Fig. 4.4 can be found the positions of SCANNING SPEED SELECTOR and SCANNING SPEED which give a speed nearest the calculated value S . From Fig. 4.5 is read the relationship between Octaves/min. and Degrees/min. for cases when the scanning speed is given in octaves/min.

4.9. Possibilities of Regulation.

Constant vibration level of the shaker table can be obtained for:

1. Displacement (D).
2. Velocity (V).
3. Acceleration Gradient (G).
4. Acceleration (A).
5. External Filter for special frequency characteristic.
6. As 5 but -6 dB/Oct.
7. Displacement below and Acceleration above a preset frequency (D-A).
8. Velocity below and Acceleration above a preset frequency (V-A).
9. Acceleration below and Acceleration Gradient above a preset frequency (A-G).

Additionally the regulation may be governed by the Programming System described in Chapter 8.

The frequency ranges covered by the various quantities and valid for the combination Accelerometer Preamplifier, Vibration Meter and Sine-Random Generator are illustrated in Table 4.2. The different vibration ranges stated correspond to the ranges available on the Vibration Meter.

Table 4.2.

Control of	Frequency range
Displacement	50-2000 Hz with DISPL.-GRAD.-VEL. range switch in position "0.01 in". 5-2000 Hz for all other positions. 5 % down at 5 Hz.
Velocity	50-2000 Hz with DISPL.-GRAD.-VEL. range switch in position "0.1 in/sec.". 5-2000 Hz for all other positions.
Acceleration Gradient	10-10,000 Hz
Acceleration	10-10,000 Hz

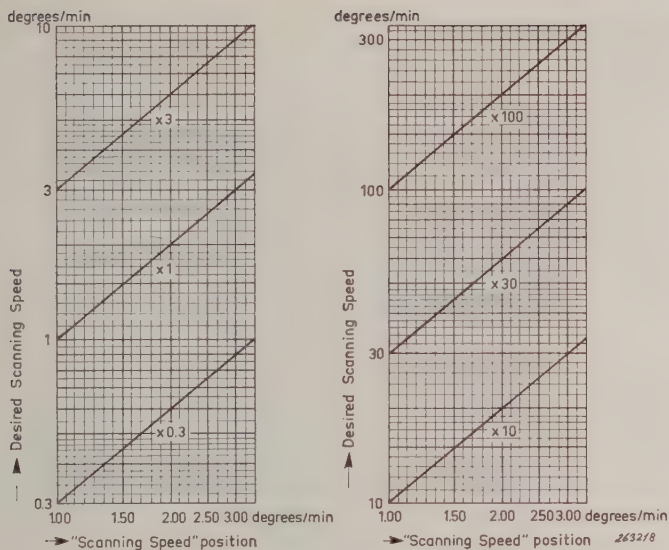


Fig. 4.4. Chart for easy determination of the "Scanning Speed Selector" and "Scanning Speed" setting.

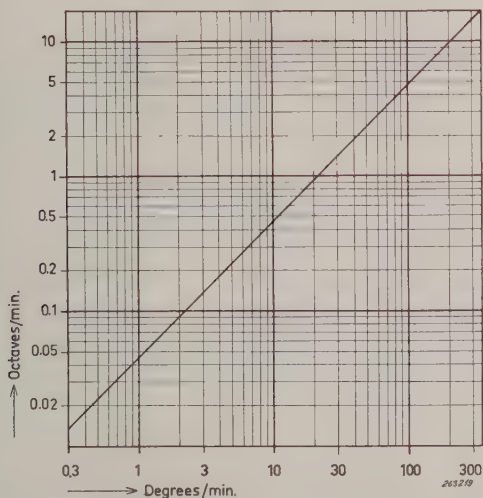


Fig. 4.5. Chart for converting scanning speed in octaves/min. to scanning in degrees/min.

4.10. Setting Auto Cross-over Frequency.

Set SCANNING switch to "Off".

Set FUNCTION SELECTOR to "Auto D-A", "Auto V-A" or "Auto A-G".

Position the frequency pointer on the desired cross-over frequency. (Anywhere between 15 Hz and 1000 Hz is possible in principle). Hold the large tuning knob stationary and turn the small knob relative to it until the cross-over point is reached. This can be seen on the lamps of the 2502 indicating Vibration Level Below and Above Cross-over.

Sweep the pointer manually through cross-over and check that the transition point is correct. Fine adjust if necessary.

4.11. Setting Compressor Speed.

The COMPRESSOR SPEED should be set to a value which suits the rate of resonance build-up during scan, and the lowest sine-wave frequency or bandwidth of noise used. Owing to the risk of noise peak clipping or sine-wave distortion the COMPRESSOR SPEED knob should not be set to higher values than stated in Table 4.3.

Table 4.3a.

"Narrow Random Bandwidth" Hz	Compressor Speed dB/sec.
3	3
10	10
30	30
100	100

Table 4.3b.

"Sine" Lowest Frequency of chosen sweep range Hz	Compressor Speed dB/sec.
5	10
30	30
100	100
300	300
1000	1000
3000	3000

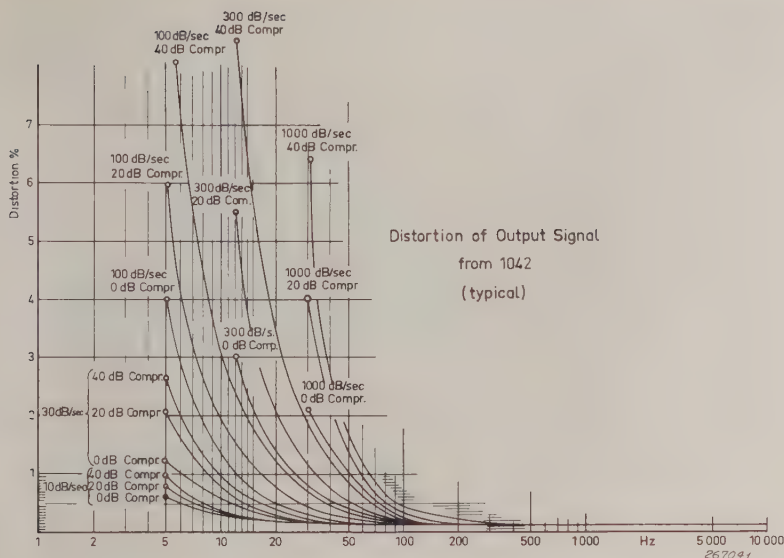


Fig. 4.6. Some distortion curves as a function of frequency for different compressor speeds.

When optimum compressor speed is required throughout the frequency range of interest, use can be made of the programmed compressor speed changing, but this is intended only for sweeping sine-wave tests. The choice of program depends upon the required distortion limits and upon instabilities in the regulation loop.

The distortion dependent upon compressor speed can be seen in Fig. 4.6. The curves show that a compressor speed as low as possible should be chosen at low frequencies. The curves also show that least distortion occurs when the amount of compression is 0 dB. It is therefore essential that the minimum compression during the sweep through the frequency range is adjusted to 0 dB (see section 4.16, Table 4.6).

Too fast compressor speed may cause instability in the regulation loop (instability shows up on a monitoring oscilloscope as amplitude modulations of the sine-wave test signal). Should instability occur during the sweep the setting of the COMPRESSOR SPEED knob should be changed to a program containing lower compressor speeds. Should it be impossible to obtain stable conditions with the COMPRESSOR SPEED knob in any of the afore mentioned positions, it is necessary to use one of the fixed, slow COMPRESSOR SPEED conditions.

Warning: Do not alter the position of the COMPRESSOR SPEED knob unless the OUTPUT VOLTAGE control is turned fully anticlockwise, and the warning lamp switched off.

4.12. Setting of MODE SELECTOR, METER TIME CONSTANT and METER INDICATION.

The setting of METER TIME CONSTANT and METER INDICATION of the Vibration Meter depends upon the chosen output spectrum determined by the generator MODE SELECTOR.

When setting METER TIME CONSTANT Table 4.4 may be used as a guide. The METER TIME CONSTANT of the generator is only incorporated when the generator meter measures the output voltage (METER SWITCH to "Output Voltage") and Table 4.4 may also in this case be used as a guide.

Table 4.4.

"Mode Selector"	"Meter Time Constant"
Sine	0.3 sec.
100 Hz bandwidth	1 sec.
30 Hz bandwidth	3 sec.
10 Hz bandwidth	10 sec.
3 Hz bandwidth	30 sec.

The position " / " (peak/peak to peak) of METER INDICATION is only intended for sine operation as they are made by increasing the meter sensitivity by $\sqrt{2}$ and $2\sqrt{2}$ respectively. For all other types of signals the RMS indication should be used.

4.13. Reading Vibration Level.

The vibration level is read on the Vibration Meter. The indicating lamps at the left hand side of the apparatus show which Range knob is used at any instant. When FUNCTION SELECTOR is set to "Ext. Filter" the ACCELERATION knob is used as attenuator and when set to "Ext. Filter - 6 dB/Oct." the attenuation is controlled by the DISPLACEMENT knob.

4.14. Vibration Level Preset.

1. Set METER SWITCH to "Vibration Level Preset", COMPRESSOR to "On" and OUTPUT VOLTAGE fully counter-clockwise so that the warning lamp is switched off.

2. Set the frequency pointer somewhere in the range which is going to be used.
3. If auto cross-over is to be employed, adjust the cross-over frequency to that required by the particular test specification (section 4.10 describes the method).
4. Set MODE SELECTOR to "Sine" or one of the "Narrow Random Bandwidth Hz" positions as required.
5. Set COMPRESSOR SPEED to the required position (see information in section 4.11).
6. Set METER INDICATION and METER TIME CONSTANT of the Vibration Meter as described in section 4.12.
7. Set FUNCTION SELECTOR and the range switches to suitable positions, see Table 4.5.
8. Adjust the VIBRATION LEVEL potentiometers to obtain the desired indication below and above the cross-over. There should normally not be a jump in level at cross-over. See the nomograph in Chapter 9.
9. Set METER SWITCH to "Stand by" and the remaining knobs to suitable positions. The vibration level preset is now completed.

4.15. Summary of Preparatory Operations.

1. Interconnect the different instruments, see Table 4.1.
2. Carry out the initial setting of controls (section 4.3).
3. Calibrate the frequency scale (section 4.4).
4. Set up the scanning range*) and scanning speed required by the particular test specification (section 4.5 to 4.8). Having done this, leave the SCANNING switch on "Off".
5. Adjust the vibration level by using the "Vibration Level Preset" facility (section 4.14).

WARNING

When the red lamp DANGER DO NOT SWITCH is alight, the knobs with red spots must not be touched by unauthorized personnel, otherwise permanent damage may be caused to the specimen and shaker table.

*) Do not forget to position FREQUENCY RANGE correctly. Also check on Table 4.2, section 4.9, that the chosen range is admissible.

Table 4.5.

	Constant Displacement	Constant Velocity	Constant Acceleration	Constant Acc. Gradient	Constant Displacement below x-over Constant Acceleration above x-over	Constant Velocity below x-over Constant Acceleration above x-over	Constant Acceleration below x-over Constant Acc. Gradient above x-over
FUNCTION SELECTOR	"Displ."	"Vel."	"Accel."	"Grad."	"Auto D-A"	"Auto V-A"	"Auto A-G"
DISPLACEMENT	as required	—	—	—	as required below x-over	—	—
VELOCITY	—	as required	—	—	—	as required below x-over	—
ACCELERATION	—	—	as required	—	as required above x-over	as required above x-over	as required below x-over
ACCELERATION GRADIENT	—	—	—	as required	—	—	as required above x-over
OUTPUT SWITCH	"High Pass"	"High Pass"	"Lin."	"Lin."	"High Pass"	"High Pass"	"Lin."

Note: There should normally not be a jump in vibration level at cross-over. See the nomograph in Chapter 9 giving equal vibration levels for different kinds of excitation quantities.

4.16. Final Check of the Set-up and Start of Test.

Set METER SWITCH to "Compression". Then proceed as follows:

Table 4.6.

Object of step	Adjustments
Open up the generator, checking that vibrations are held down by control loop.	Turn OUTPUT VOLTAGE slowly clockwise (at low compressor speed very slowly) and check on meter scale of the Vibration Meter that vibrations do not exceed desired level. The generator meter indicating compression will under this process show an increasing deflection.
Adjust gain so that generator operates over optimum regulation characteristic.	Adjust OUTPUT VOLTAGE so that as frequency pointer is swept manually through, minimum compression is in the vicinity of 0 dB but not less. (Choose suitable Power Amplifier gain; this is complementary to OUTPUT VOLTAGE setting).
Start test and check levels.	Set SCANNING to "On" and observe one sweep. Trim VIBRATION LEVEL controls if necessary.
Check compression.	Re-check that the pointer of the generator meter (showing compression) does not go to the right of 0 dB. Trim OUTPUT VOLTAGE if necessary.

TO STOP a test at any point, turn

SCANNING to "Off"

and

METER SWITCH to "Stand by"

simultaneously

Re-start the same test by returning

METER SWITCH to "Compression" (or "Output Voltage") and SCANNING to "On".

This is particularly useful when changing specimens on the shaker table.

4. OPERATION

To change from one kind of test to another, turn

SCANNING switch to "Off".

OUTPUT VOLTAGE fully anticlockwise (the warning lamp switches off).

METER SWITCH to "Vibration Level Preset".

Then set up the new test, following sections 4.15 and 4.16.

5. Operation with Level Recorder

5.1. Possibilities.

The frequency scan of the Sine-Random Generator Type 1042 can be synchronized with the paper drive of the B & K Level Recorder, Type 2305. The synchronization may be made in two ways:

1. By using the six scanning speeds made especially for operation with the Level Recorder.
2. By using the Motor Drive UM 1018.

If frequency calibrated chart paper is used in the Level Recorder, direct plots of vibration levels (to a variety*) of logarithmic and linear scales) can be obtained against frequency. This convenient presentation of information is particularly useful for

- A. Monitoring the motion of the shaker table (section 5.3).
- B. Charting the combined frequency response of the power amplifier, shaker table and specimen (section 5.4).
- C. Recording the vibration level of some part of the specimen, i.e. to measure resonances etc. (section 5.5).

5.2. Synchronization with Level Recorder.

1. *Use of the six special scanning speeds:*

Before measuring any of these vibration levels the frequency scanning system of the 1042 must be linked and synchronized with the paper drive of the Level Recorder. There are two possibilities;
either, I, the whole system can be started and stopped manually by turning the 1042's SCANNING switch.

or, II, a single sweep can be initiated by pressing the SINGLE CHART button on the Level Recorder, the system then being stopped automatically after one chart has run off.

I. *Manual Stop.*

- a. Insert roll of recording paper (QP 0123, QP 0423 or QP 1123) into Level Recorder. For details, see Instruction Manual for Type 2305.
- b. On Sine-Random Generator set
SCANNING SPEED SELECTOR to one of the six right hand side positions
SCANNING switch "Off"

*) The dynamic range of Type 2305 depends on which special potentiometer is fitted to it
A 50 dB potentiometer is delivered as standard but the following are available: 10, 25, 50 or 75 dB logarithmic; 10 to 35 or 10 to 110 linear.

5. OPERATION WITH LEVEL RECORDER

- c. Unscrew Reversing Arm (see Fig. 4.2). For clockwise scanning, leave reversing switch in right-hand position and reduce "active" frequency range by means of cam discs (see section 4.7) if required.
- d. Interconnect Level Recorder's REMOTE CONTROL socket with the 1042's SWEEP CONTROL A as illustrated in Fig. 5.1.
- e. On Level Recorder, set

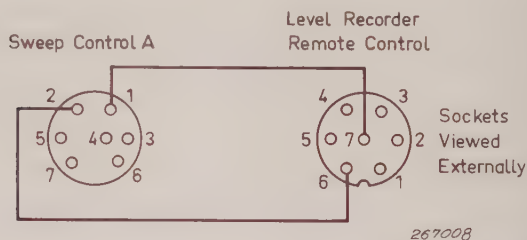


Fig. 5.1. To control the Level Recorder from the Sine-Random Generator connect the two instruments as shown here. Both sockets viewed externally.

PAPER DRIVE "Start" and "Forward"

SINGLE CHART in upper position

PAPER SPEED. See Table 5.1. Use the *large figures* around this knob "Gear Lever X" (Button on right-hand side). *Push in*.

POWER "On"

MOTOR "On"

Table 5.1.

Correlation between scanning speeds and paper speeds. The meaning of "pulse interval" will be clear from item k.

SCANNING SPEED SELECTOR position degrees/min.	0.864	2.59	8.64	25.9	86.4	259
Level Recorder PAPER SPEED mm/sec.	0.01	0.03	0.1	0.3	1	3
Pulse interval for 1042 drivemotor, millisecs.	50.00	16.67	5.000	55.54	16.66	5.554

- f. Set frequency pointer of 1042 to frequency where scan and record should commence.
- g. Adjust position of recording paper by Finger Wheel Z until pen covers frequency graduation corresponding to f.
- h. Start scan and paper drive by switching 1042's SCANNING switch to "On".

- j. Stop at any point (less than one sweep or after several sweeps, as required) by turning SCANNING switch to "Off" and METER SWITCH to "Stand By".*)
- k. Fine adjust 1042's scanning speed by the screwdriver operated Speed Trim control if required. (Located between the two SCANNING SPEED knobs). By trial and error it is possible to find a setting such that after a few sweeps the frequency pointer and the pen still agree. Alternatively, check, by means of an electronic counter that the 1042's sweep motor is being driven at exactly the right frequency. Connect the counter between chassis and pin 4 of SWEEP CONTROL B. Ideally the pulse repetition period seen here should be as given in Table 5.1. However, remember that the exact paper speed depends on the mains period and if this deviates from 20 msec or 16.67 msec**) the tabulated values must be adjusted accordingly.

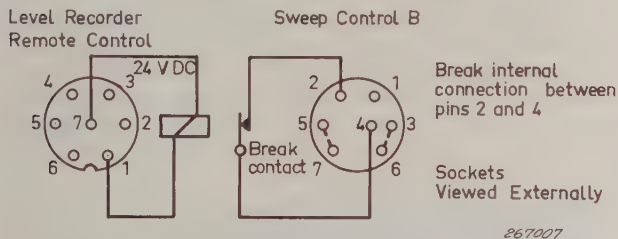


Fig. 5.2. If connected in this way, the system is started by pressing the SINGLE CHART button of the Level Recorder. Scanning stops automatically after one chart has been run off.

NOTE: Take out the interconnection (at the rear of the socket) between pins 2 and 4. The relay can, if convenient, be left coupled to the 1042 after the 7-pole plug has been removed from its socket on the Level Recorder; the 1042 is then in the same condition as when delivered.

II. Single Chart, Auto Stop.

- m. Repeat items a, b and c above.
- n. Following Fig. 5.2, connect Level Recorder's REMOTE CONTROL socket to a 24 V relay. A break contact on the relay then replaces a shorting link normally present on the back of the 1042's SWEEP CONTROL B socket. Keep the other two shorting links, pins 3-6 and pins 5-7, in position.

*) Note: If several records are to be exactly superimposed, it is possible to run the system backwards by flicking the Reversing Switch on the 1042 to the left with a small screwdriver and moving the Level Recorder's PAPER DRIVE to "Reverse". Then stop and run forwards again. These controls must only be changed when SCANNING switch is on "Off".

**) i.e. if the frequency deviates from 50 Hz or 60 Hz. (The Level Recorder gears can be arranged for operation at either 50 Hz or 60 Hz.).

- p. On Level Recorder, set
PAPER DRIVE "Start" and "Forward"
SINGLE CHART in upper position
PAPER SPEED. See Table 5.1. Use the *small figures* around this knob
Gear Lever X Pull out
POWER "On"
MOTOR "On". Wait for paper to stop.
- q. Repeat items f and g.
- r. Turn the 1042's SCANNING switch to "On". Nothing should happen.
- s. Start scan and paper drive by depressing the Level Recorder's SINGLE CHART pushbutton for a few seconds, then releasing it. When the scan has stopped automatically, the 1042's frequency pointer should be in the same position as it was initially.*) If it is not, follow procedure k.

2. *Use of the Motor Drive UM 1018:*

The Motor Drive UM 1018 has been designed for synchronous operation of the Level Recorder Type 2305 with the B & K vibration test generators. It is an external motor which is screwed onto the Level Recorder drive shaft and driven with pulses from the oscillator which also drive the sweep motor of the generator. Complete synchronism is thereby obtained

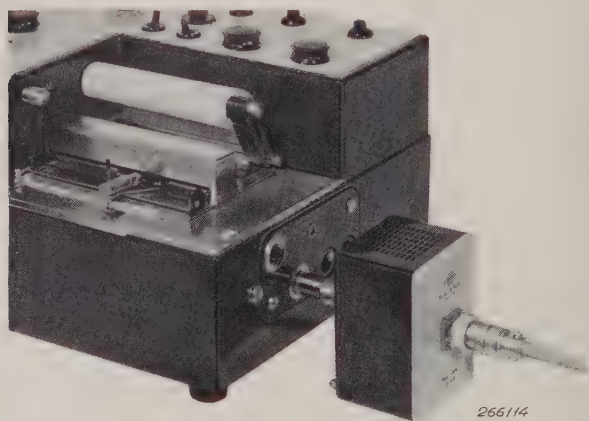
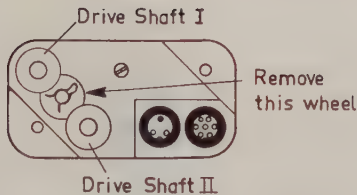


Fig. 5.3. Photograph of the Motor Drive UM 1018 mounted on the Level Recorder.

*) When superimposing similar recordings it may be useful to back-track the whole system. To do this, flick the Reversing Switch on the 1042 to the left with a screwdriver and move PAPER DRIVE to "Reverse". Press SINGLE CHART and wait till the paper is back at the starting point. Do not forget to return both direction controls before recording again.

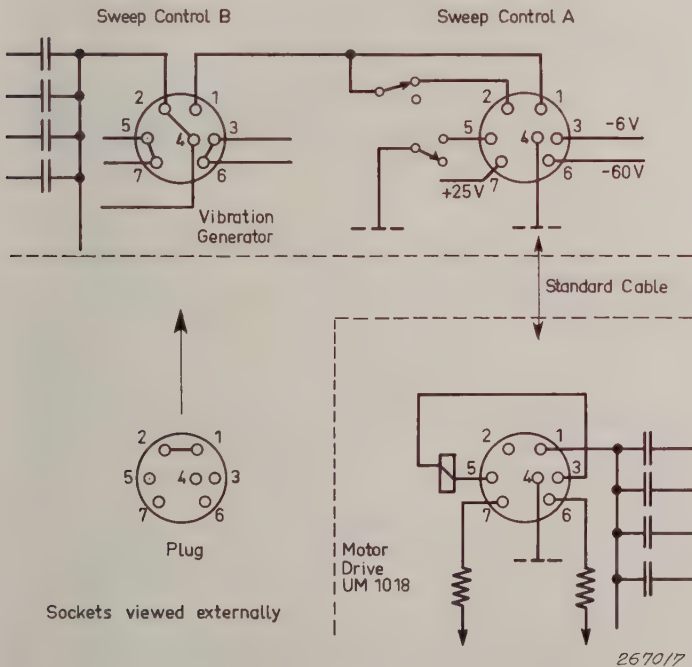


266104

Fig. 5.4. Remove nylon gear wheel as shown.

in both forward and backward sweep directions, and for any number of sweep cycles.

The motor is screwed onto DRIVE SHAFT II of the Level Recorder after removal of the gear wheel shown in Fig. 5.4, and connected to the generator as shown in Fig. 5.5.



267017

Fig. 5.5. Connection of the Motor Drive to the generator.

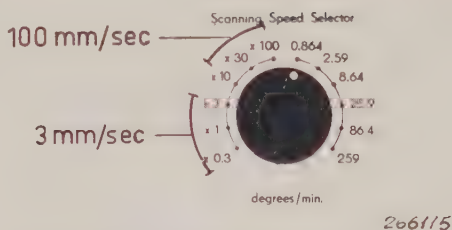


Fig. 5.6. Set PAPER SPEED on Level Recorder as indicated.

When used with the Motor Drive UM 1018 the Level Recorder PAPER SPEED switch is set to 100 or 3 mm sec depending upon the setting of the generator sweep speed. See Fig. 5.6. The SYNCHRONIZING GEAR LEVER on the Level Recorder is pushed in and the DRIVE SHAFT SPEED switch should be in position 120 RPM.

5.3. Monitoring Shaker Table Motion.

This is not always informative, since either one or two straight lines are expected if the level control is good. Nevertheless it is useful to have indisputable evidence of the test conditions. The principle is simply to run the test as described in Chapter 4, but to monitor and plot the vibration signal which is being used to control the shaker table.

The arrangement is as shown in Fig. 5.7.

I. Set Level Recorder's amplifying and writing system:

POTENTIOMETER RANGE "Stand by"

RANGE POTENTIOMETER Insert correct one, 10 dB, 25 dB, 50 dB, 75 dB, 10/35 Lin, 10/110 Lin.

POTENTIOMETER RANGE Set to correspond with above, viz: "10", "25", "50", "80", "12", "16" respectively

LOWER LIMITING FREQUENCY "10 Hz"

WRITING SPEED "40/80"

RECTIFIER RESPONSE "RMS"

INPUT ATTENUATOR "60 dB"

INPUT POTENTIOMETER "0"

II. Start Scan.

In manual control case by switching 1042's SCANNING switch to "On".

In single chart auto stop case by pressing the Level Recorder's SINGLE CHART button.

III. Set Plotting Level.

During a trial run adjust INPUT ATTENUATOR and INPUT POTENTIAL-METER so that the ordinates of the chart can be easily related to the meter scale of the Vibration Meter.

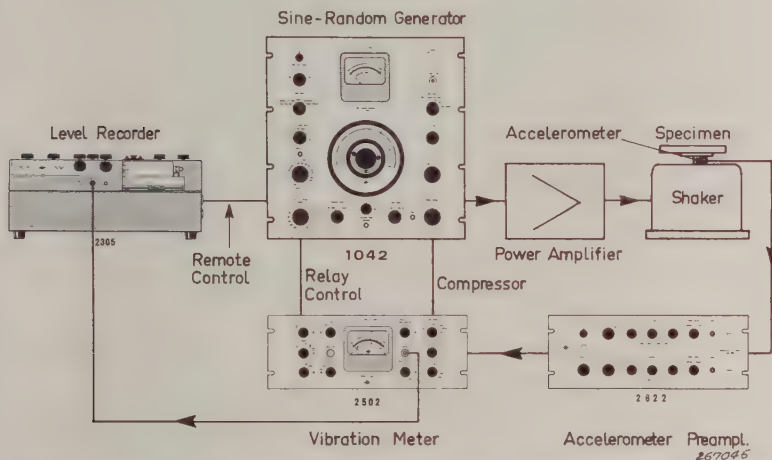


Fig. 5.7. Vibration test system coupled to a Level Recorder which plots vibration levels at the shaker table.

5.4. Plotting System Frequency Response.

It is sometimes interesting to chart the open loop frequency response of the system from Generator output to shaker table. There are two ways of doing this:

I. Open Loop, Measuring Table Vibration.

For safety reasons, this method is NOT RECOMMENDED. However, with complicated systems it can be argued that it is necessary, in which case proceed as in Fig. 5.7, but with COMPRESSOR switch of the 1042 set to "Off".

Note: Increase OUTPUT VOLTAGE extremely carefully and watch the vibration level at all frequencies of interest to see that, even at resonance, no damage is done. Away from resonance frequencies, the vibration level will be very low.

II. Closed Loop, Inverse Characteristic.

Since the closed loop system always strives to maintain constant level at

5. OPERATION WITH LEVEL RECORDER

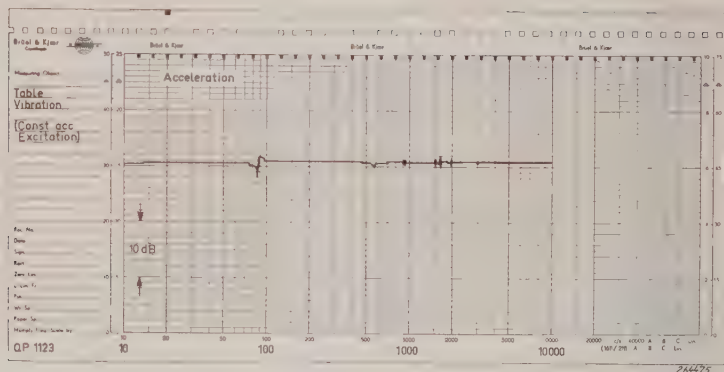


Fig. 5.8. Example of Level Recorder chart showing table vibration levels as a function of frequency. Constant acceleration control.

the shaker table, the inverse of the required characteristic is to be seen at the OUTPUT socket.

Therefore it is only necessary to set up the closed loop system under proper operating conditions using the same set-up as in Fig. 5.7 but now to connect the OUTPUT socket at the back of the 1042 to the Level Recorder INPUT as well as to the power amplifier. A curve as that of Fig. 5.9 results.

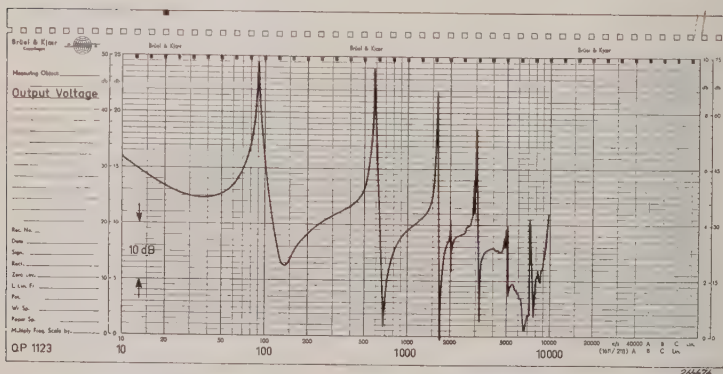


Fig. 5.9. Example of inverse characteristics of power amplifier plus shaker table. It is actually the voltage on the OUTPUT socket which is plotted here.

5.5. Recording Specimen Vibration.

The intention here is to record the resonances of the specimen so a second transducer is required. The second channel of the Accelerometer Preamplifier Type 2622 is used for matching and calibrating the output from the monitoring accelerometer, but the signal must be amplified before being fed to the Level Recorder Input*). A Vacuum Tube Voltmeter Type 2416 forms a convenient calibrated amplifier for this purpose; see the arrangement of Fig. 5.10.

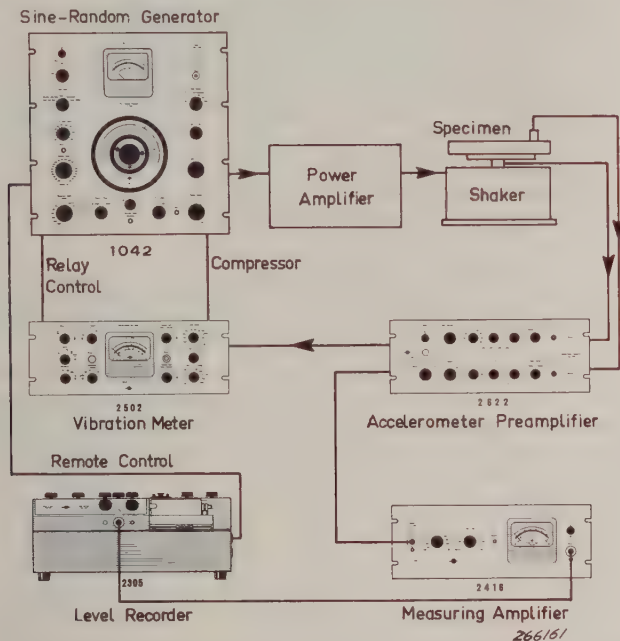


Fig. 5.10. Vibration test system in which the vibrations of the specimen are plotted on a Level Recorder.

Follow the same procedure as in "Monitoring Shaker Table Motion" but this time adjust the Level Recorder's INPUT ATTENUATOR and INPUT POTENTIOMETER so that the ordinates of the chart can be easily related to the 2416 voltmeter's scale.

A typical record appears in Fig. 5.11.

*) If another quantity (e.g. displacement) is to be derived, an amplifier with shaping networks will be needed. One solution is to route the monitor accelerometer direct to an Accelerometer Preamplifier Type 1606, which can perform one or two integrations. Type 1606 must be powered from, for instance, a Microphone Amplifier Type 2603. The latter also takes the place of the Voltmeter Type 2416.

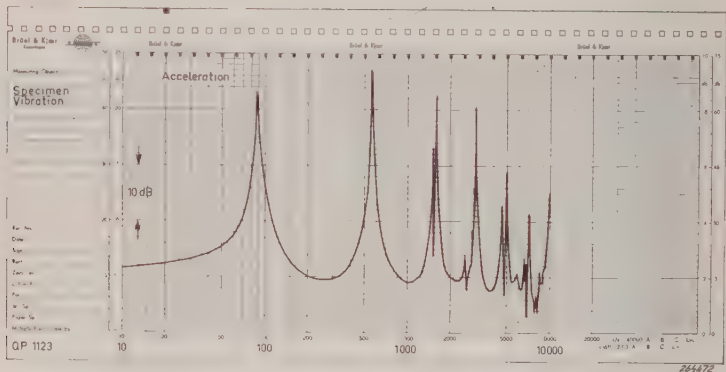


Fig. 5.11. Example of acceleration levels at the top of a specimen shaken at constant acceleration.

5.6. Recording Two Quantities Simultaneously.

Two quantities, say table vibration and specimen vibration, can be recorded "simultaneously" if the Level Recorder's Two Channel Selector is used, see Fig. 5.12.

This selector is a change over switch which is actuated from the recorder's Drive Shaft II. Set this up as described in the Level Recorder manual, using a 180° cam disc (OD 0059).

Choose a position of Drive SHAFT SPEED R.P.M. such that the pen has time to take up position relative first to one signal and then to the other, still maintaining resolution.

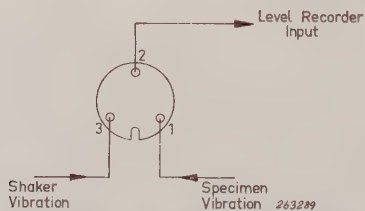


Fig. 5.12. Method of connecting the Two Channel Selector on the Level Recorder.

6. Remote Control Facilities

6.1. Start and Stop of Automatic Frequency Scan.

Connect a switch or pushbutton to the socket SWEEP CONTROL B as shown in Fig. 6.1.

Note: Remove interconnection (placed on rear of socket) between 2 and 4. When the switch is opened the frequency scan stops immediately.*)

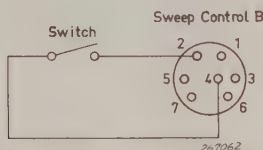


Fig. 6.1. Connection of an external switch for remote start and stop of the automatic frequency scan.

6.2. Forward and Reverse Frequency Scan.

1. Unscrew reverse-switch arm located in the Generator Frequency Scale guide plate. (See Fig. 4.2).

Warning. If the reverse-switch arm is not removed the scanning drive will be damaged as the scanning is not reversed when the finger screw for the high frequency scan limit setting reaches the arm.

2. Set reverse-switch arm in backwards scan position i.e. to its left hand position.
3. Connect a pushbutton to the SWEEP CONTROL A socket as illustrated in Fig. 6.2.
4. Set SCANNING switch to "On".
When operating the pushbutton i.e. closing the contact, the frequency scan will run forwards.

*) When employing the Brüel & Kjær Level Recorder Type 2305 in the vibration system start and stop of its paper drive can also be remotely controlled.

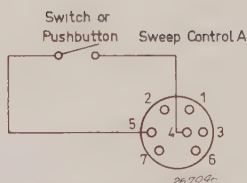


Fig. 6.2. Connection of an external push-button for reversing remotely the direction of the frequency scan.

6.3. Stand by.

The stand by facility can be remotely controlled when a switch or pushbutton is connected to the socket 50-60 kHz as shown in Fig. 6.3. By closing the contact the Generator is set to stand by.

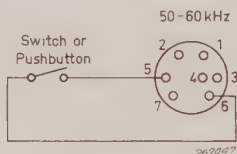


Fig. 6.3. Switch connection for remote control of the "stand by" function.

6.4. Changing Scanning Speed.

Sometimes it may be useful to scan slowly through a resonance but rapidly through the rest of the frequency range.

Method I:

If the pulse repetition frequency of an external pulse generator can be suitably programmed, feed its signal*) onto pin 2 of SWEEP CONTROL B, having broken the link to pin 4.

Method II:

- Set for the slower speed (through the resonance), one of the following settings of SCANNING SPEED SELECTOR:
 $\times 0.3$ ", " $\times 1$ ", " $\times 3$ ", " 0.864 ", " 2.59 ", " 8.64 ".
- Wire up SWEEP CONTROL B as shown in Fig. 6.4.
- Arrange, perhaps with a switch actuated by a tuning spindle extension, that the speed changes at suitable frequencies. The faster speed (through the uninteresting sectors) is 33 times the speed indicated by the knob settings. In other words, the change is equivalent to rotating the SCANNING SPEED SELECTOR three clicks clockwise.

*) Chassis negative, positive-going pulses of between 4 V and 10 V magnitude to pin 2.

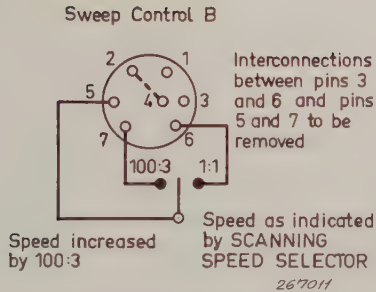


Fig. 6.4. How to increase the lower sweep speeds by a factor of 100 to 3. This is useful when "skipping" uninteresting parts of the frequency range. Note that the interconnections at the rear of the socket between pins 3 and 6 and between pins 5 and 7 must be removed.

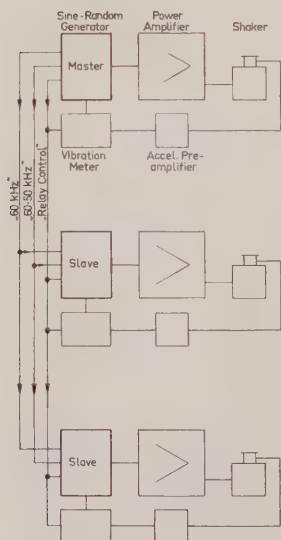
7. Master-Slave System

7.1. Principles.

As explained in section 2, the outputs from all the Sine-Random Generators originate in the fixed and variable oscillator signals of the master unit. This is illustrated in Fig. 7.1, which also shows that the compressor loops are separate, though the compressor speeds are all switched by the master. Two slave units are shown but in principle there is no limit to the number used. In practice however, no more than three slaves should be connected owing to the risk of overloading the 6 V DC supply in the master. Also the maximum capacitive load which is applied to the fixed and variable oscillators in the master unit should be less than 2 nF.

If it is desired to build up a Master-Slave System in combination with the Programming System described in Chapter 8 it is necessary to incorporate an external 6 V DC supply for the relays.

Principle of Setting Up



Principle of Operation

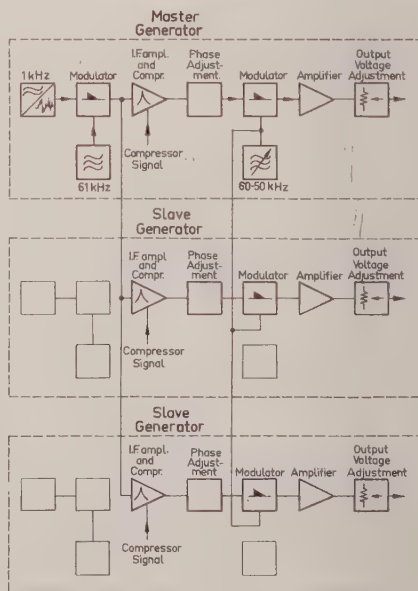


Fig. 7.1. "Master slave" arrangement of 3 Sine-Random Generators.

7.2. Interconnections.

Wire up the individual systems as described in Chapter 4.

In addition, interconnect the sockets of the master and of the slaves as shown in Fig. 7.2.

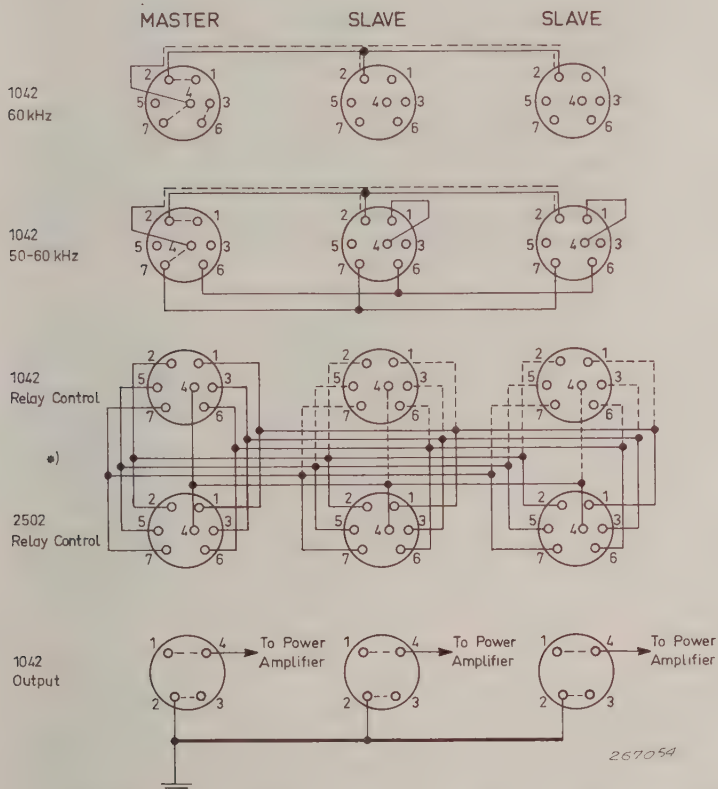


Fig. 7.2. Socket interconnections for "master slave" arrangement including three systems.

Note: Connections shown are additional to the internal connections of the individual systems.

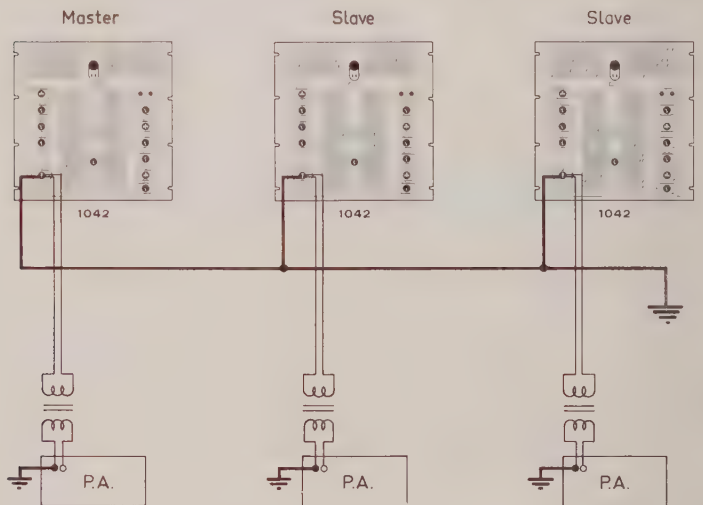
Note: The connection between pins 1 and 2, 3 and 6, and 4 and 7 of the 60 kHz socket and between pins 1 and 2, and 4 and 7 of the 50-60 kHz socket should be removed on all slaves.

*) Standard Cable AO 0058 and Connection Box JJ 0036 may be used for the interconnection.

Keep all the generator units close together. Each power amplifier must be fairly near to its associated shaker so if it is necessary to space out the shakers, the long leads should be those connecting the generators to the power amplifiers.

The high frequency potentials of the various chassis may not be exactly equal, so to prevent transients due to relay switching etc. from influencing the output signals, it is advisable to connect all the earthy pins on the OUTPUT sockets together and take them to a good ground point. Use thick short wires.

It is usually advisable to directly earth the chassis of the power amplifiers. To prevent these earths forming a ground loop via the earth point mentioned above, the power amplifiers should each be fed through a transformer. Provided the transformers are located in close proximity to the power amplifier inputs, ordinary inexpensive input transformers may be used; their frequency characteristic is not important since any peculiarities are regulated out by the system.



267055

Fig. 7.3. Arrangement of earths to give minimum noise trouble.

7.3. Setting Up.

1. Set up the master unit as for an ordinary test. (See Chapter 4).

The interconnections shown in Fig. 7.2 are intended for the programmed compressor speeds. If one of the fixed compressor speeds is preferred, short-circuit pins 4 and 7 of the 60 kHz sockets and disconnect the Relay Control plugs of all slaves (dashed lines in Fig. 7.2, 1042 Relay Control).

If cross-over is required the interconnections for pins 1 and 4 should be kept.

After testing the master system alone, set METER SWITCH to "Vibration Level Preset" and SCANNING to "Off".

II. Set controls on all slaves.

OUTPUT VOLTAGE Fully anticlockwise.

SCANNING "Off"

METER SWITCH "Vibration Level Preset"

OUTPUT SWITCH As required

COMPRESSOR "On"

COMPRESSOR SPEED As used on the master

Frequency pointer to somewhere between 10 and 25 Hz on scale.

(Note: The pointer has to be placed within this range to avoid the compressor and stand-by relays being energized. The pointer can be locked in position by the Frequency Scanning Range stop crews). Cross-over point well above 25 Hz.

7.4. Adjusting Individual Vibrations (Level and Phase).

Set the vibration levels on the slave shakers, once again using the principles outlined for setting up a single system. Frequency (including cross-over) is governed by the master, but adjust each slave's OUTPUT VOLTAGE and vibration RANGE and LEVEL controls so that the vibration levels are as required – not necessarily the same for all shakers. Do *not* turn any slave's SCANNING switch to "On". The desired phase relationship between the movement of the master and slave shaker table can be adjusted on the individual master and slave. The adjustment is effected by the screwdriver operated front panel control PHASE. The shifting range is approximately 150° on each unit, and by reversing the drive coil connections on the shaker an additional 180° phase shift is obtained.

7.5. Command of the System.

Start the automatic frequency scan of the complete arrangement by setting the master's SCANNING switch to "On".

The vibration levels of all shakers can be cut down practically instantaneously by switching *the master's*) METER SWITCH, to "Stand-by".

To kill the vibration of one shaker only the OUTPUT VOLTAGE of the relevant generator is turned fully anticlockwise so that the warning lamp is switched off (the stand by cannot be used as it affects all shakers).

Any of the remote control facilities outlined in Chapter 6 can be applied to a complete master-slave arrangement. The connections must be made to the master unit.

*) It appears possible to stand-by the whole system with any of the METER SWITCHES. However do not use this on any of the slaves because the stand-by relay circuit then becomes grounded at more than one point, thus causing hum problems (Hum about 50 dB below vibration level).

8. Programming System

8.1. Description.

In Fig. 8.1 is shown a system with various possibilities for advanced programming of the vibration test.

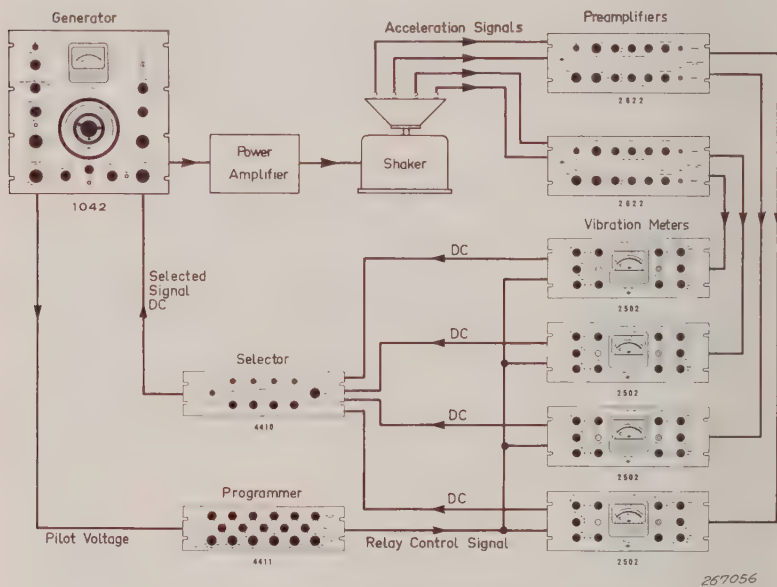


Fig. 8.1. Complete vibration test set-up.

It should be noted that this is a fairly complex system. Such a powerful set-up is not required for all types of applications. Some may only need the simple 2622 – 2502 – 1042 combination. The various possible instrument combinations are described in section 8.5.

Returning to Fig. 8.1 it is seen that the excitation signal to the shaker is supplied by a Sine-Random Generator Type 1042 via a power amplifier. The sweep is automatic and the output signal is regulated by a feedback signal derived from the acceleration measured on the shaker table or on the specimen being tested. When the Control Signal Selector Type 4410 is employed, it is possible to control the vibration from up to four accelerometers simultaneously.

Suitable accelerometers are the B & K Piezoelectric Accelerometers Type 4332-40.

Accelerometer Preamplifiers Type 2622 are used for impedance conversion of the high impedance signals from the accelerometers. A separate instruction book is issued for the Preamplifier, where a more thorough description is given, suffice it here to say that it is a two-channel preamplifier which may be switched to operate as a charge amplifier or as a voltage amplifier, and that its outputs are scaled to 10 mV/g.

The Vibration Meters Type 2502 are used for reading the vibration at the points where the accelerometers are placed, and for supplying DC signals to the Control Signal Selector. These DC signals are proportional to the average values of the vibration quantities measured. The Vibration Meters contain integration networks for conversion of the acceleration signals to acceleration gradient (-3 dB/octave), velocity (-6 dB/octave) and displacement (-12 dB/octave), so that any of these four quantities may be measured and controlled. The Control Signal Selector may be set to select the "Highest", the "Lowest" or the "Average" of up to four signals and will transmit the selected signal to the compressor circuit of the generator whereby the highest, lowest or average vibration is kept constant over the frequency sweep. Any one of the four signals may also be selected manually, whereby the vibration at the corresponding point is controlled.

The functioning of the Vibration Meters is controlled by the Vibration Programmer Type 4411, using a DC voltage proportional to the logarithm of the frequency from the generator sweep mechanism. Relay circuits in the Programmer are set to switch the function selector of the Vibration Meters five times in any frequency sweep, so that six frequency sub-ranges may be chosen, with control of different functions in each range. The functions available are

- Acceleration
- Acceleration Gradient
- Velocity
- Displacement
- External Filter

and a 20 dB sensitivity reduction for each function. The required function is individually pre-selected for each frequency sub-range and any combination of functions is possible.

The built-in weighting networks will be found sufficient for most applications, but for special frequency characteristics the external filter facility is a convenient feature.

An example of a combination of functions for a frequency sweep is shown in Fig. 8.2.

It should be noted that the system will work equally well with only two accelerometers, one Preamplifier and two Vibration Meters, as the Control Signal Selector can be used with any number of signals up to four (although its purpose may be lost if only one signal is used).

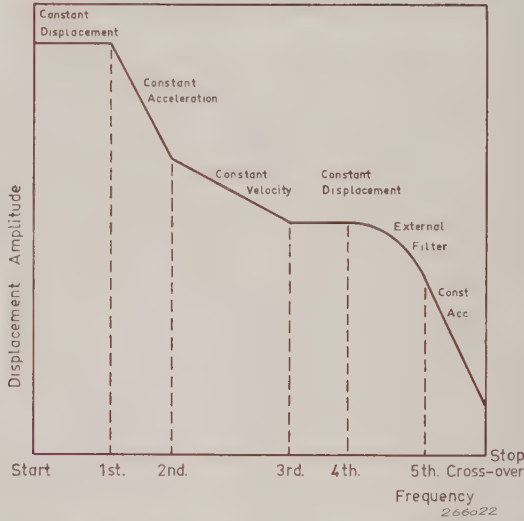


Fig. 8.2. Possible combination of functions for a frequency sweep test.

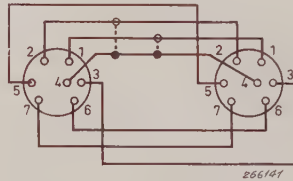
If it is desired to build up a Programming System in combination with the Master-Slave System described in Chapter 7 it is necessary to incorporate an external 6 V DC supply for the relays.

8.2. Interconnections.

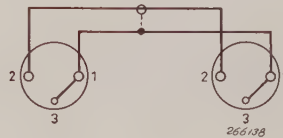
In the following the various combinations are shown schematically, and their main features are outlined. Diagrams of the relevant connecting cables are also given, to facilitate interconnection of the instruments.

The following cables are used:

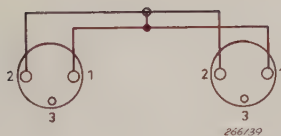
Standard



Type E



Type F



In order to simplify the illustrations somewhat, the power amplifier, shaker, test specimen and accelerometers are left out in the following combinations. (A complete system was shown in Fig. 8.1).

The cable connections in the illustrations are labelled, the upper half of the circles indicating the type of cable, and the lower half indicating the connection of the cable in accordance with the following table:

1. From DC OUTPUT of 2502 to CHANNEL INPUT of 4410.
2. From COMPRESSOR VOLTAGE of 4410 to COMPRESSOR of 1042.
3. From VIBRATION LEVEL POTENTIOMETERS of 4410 to VIBRATION LEVEL POTENTIOMETERS of 4411.
4. From REMOTE FUNCTION SELECTOR of 4411 to REMOTE FUNCTION SELECTOR of 2502, via a connection box if there is more than one 2502.
5. From the pilot voltage output socket of 1042 to PILOT VOLTAGE of 4411.
6. From RELAY CONTROL of 1042 to RELAY CONTROL of 2502, via a connection box if there is more than one 2502.
7. From OUTPUT A or OUTPUT B of 2622 to ACCELERATION INPUT of 2502. In order to avoid ground loops the accelerometers should be isolated from ground and each Preamplifier Type 2622 should only be grounded at one point. One E cable and one F cable are therefore used for each preamplifier as shown in the figures.
8. From VIBRATION LEVEL POTENTIOMETERS of 4410 to VIBRATION LEVEL POTENTIOMETERS of 2502. The connection between pins 1 and 7 in 2502 to be removed.
9. From CONTROL SIGNAL OUTPUT of 4411 to COMPRESSOR INPUT of 1042.
10. From VIBRATION LEVEL POTENTIOMETERS of 2502 to VIBRATION LEVEL POTENTIOMETERS of 4411.
11. From CONTROL SIGNAL OUTPUT of 2502 to COMPRESSOR INPUT of 1042.

8.3. Modification to Generator.

When connecting up the 1042 in combinations I and II below, the short-circuiting link between pins 3 and 6 of the COMPRESSOR socket should be removed.

8.4. Modification to Vibration Meter.

The short-circuit between pins 1 and 3 of the VIBRATION LEVEL POTENTIOMETER socket of the Vibration Meter which is used for presetting the vibration level should be removed for all combinations with Generator Type 1042.

8.5. Combinations.

Combination I.

Fig. 8.3 shows a system which utilizes the whole instrument range. There are four control accelerometers (B & K Type 4332-35 or 4340), two 2-channel preamplifiers and four Vibration Meters. Thus the vibration is controlled at up to four positions and the frequency range is split up into six sub-ranges with individual function and level control.

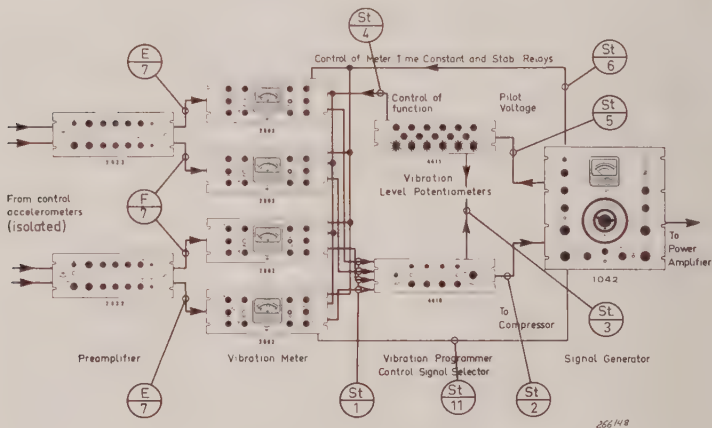


Fig. 8.3. Combination I.

Combination II.

When the Vibration Programmer is left out, as in Fig. 8.4, only two frequency subranges are retained and the cross-over is achieved with a relay in the Vibration Meter, controlled by a switch on the sweep mechanism of the generator. The cross-over may be from "Displacement" to "Acceleration", from "Velocity" to "Acceleration" or from "Acceleration" to "Acceleration Gradient". The remaining combinations of two functions may be obtained by short-circuiting appropriate sockets at the back of the Vibration Meter.

The vibration level is controlled by the level potentiometers of the Vibration Meter whose potentiometers act as external potentiometers for the Control Signal Selector irrespective of which channel is selected, as the control signals to the Selector are taken out before the potentiometers.

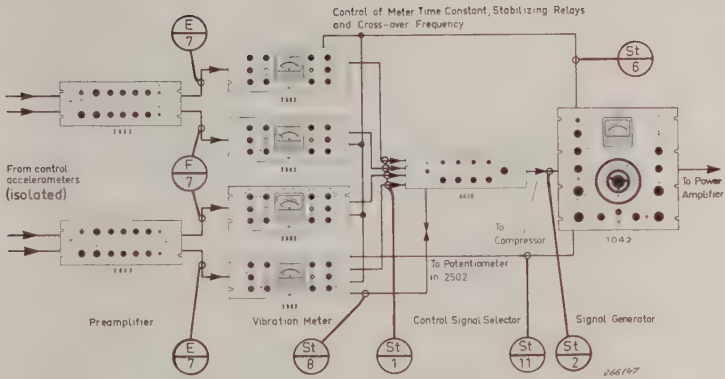


Fig. 8.4. Combination II.

Combination III.

Leaving out the Control Signal Selector, as shown in Fig. 8.5, results in a system which has five cross-over frequencies, but which employs only one control accelerometer at any time. The Preamplifier Type 2622 has two channels, so that two accelerometers may be used, and a switch-over from one to the other can be done automatically at some pre-selected frequency, for example by using the generator switching at 30 – 100 – 300 Hz or the "cross-over" switch.

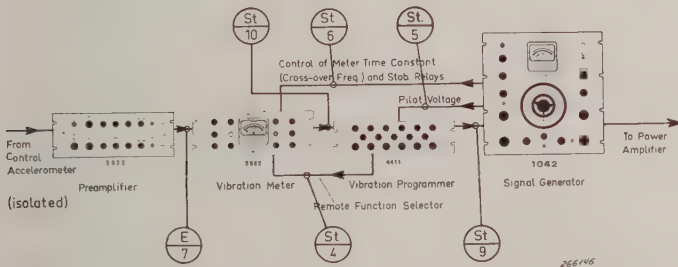


Fig. 8.5. Combination III.

Combination IV.

The set-up in Fig. 8.6 has one cross-over frequency with function combinations as that of Fig. 8.4. Only one control accelerometer is used at any one time. The Preamplifier Type 2622 has two channels, so that two accelerometers may be used, and a switch-over from one to the other can be done auto-

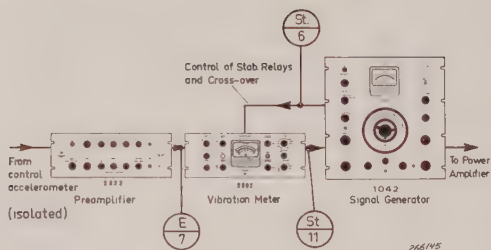


Fig. 8.6. Combination IV.

matically at some pre-selected frequency, for example by using the generator switching at 30 – 100 – 300 Hz, or the "cross-over" switch.

8.6. Operation.

1. Connect the instruments as indicated by the relevant figure. When more than one Vibration Meter is used, the cable marked 11 should be connected to the one on which the vibration level is to be preset.
2. Make sure that the mains voltage selector at the back of each instrument is in the correct position.
3. Turn all level controls and the Generator OUTPUT VOLTAGE to zero.
4. Switch on the power and allow five minutes warm-up time.
5. Calibrate the frequency scale of the generator as described in section 4.4 and set the frequency pointer somewhere in the range which is going to be used for the test. Set the cross-over frequencies to the required positions. (Set the cross-over on the Generator outside the frequency range if the Vibration Programmer is used).
6. Set the METER SWITCH of the Generator to "Vibration Level Preset" and COMPRESSOR to "On".
7. Set the FUNCTION SELECTOR and the range switches of all the Vibration Meters to suitable positions, for example to preset a vibration level of 0.3 in/sec velocity, the FUNCTION SELECTOR is set to "Vel" and the VELOCITY range switch is set to 1 in/sec.
8. Adjust the VIBRATION LEVEL potentiometers to obtain the desired indication in the various frequency sub-ranges chosen. (Below and above each cross-over).
9. Set METER SWITCH to "Stand by", and all other switches to suitable positions.
10. Set the METER SWITCH to "Compression" and turn up the OUTPUT VOLTAGE of the Generator very slowly seeing that the compressor loop suppresses the vibration amplitude.

- If the vibration amplitude is excessive, turn the OUTPUT VOLTAGE fully counter-clockwise again and locate the cause.
11. If the compressor loop is working properly, the testing may be started. The OUTPUT VOLTAGE control of the Generator should be adjusted so that minimum compression during sweep is in the vicinity of 0 dB but not less. The amount of compression can be read on the generator meter when METER SWITCH is in position "Compression".

9. Conversion Charts, Tables etc.

The following table is given in order to facilitate the conversion from dB to a (voltage) ratio. It is used as follows:

Subtract a whole number of $n \times 20$ from the dB value to be converted which gives a positive remainder between 0 and 20. Look up the ratio in the table corresponding to the remainder. The value sought is then $10^n \times$ value from the table.

Example: Convert 65.3 dB re. 1 g into units of g.

$$65.3 = (3) \times 20 + 5.3.$$

5.3 gives from table 1.841. The g-value is then $10^3 \times 1.841 = 1841$ g.

With negative values the procedure is the same, e.g.:

Convert -31.8 dB re. 1 g into units of g.

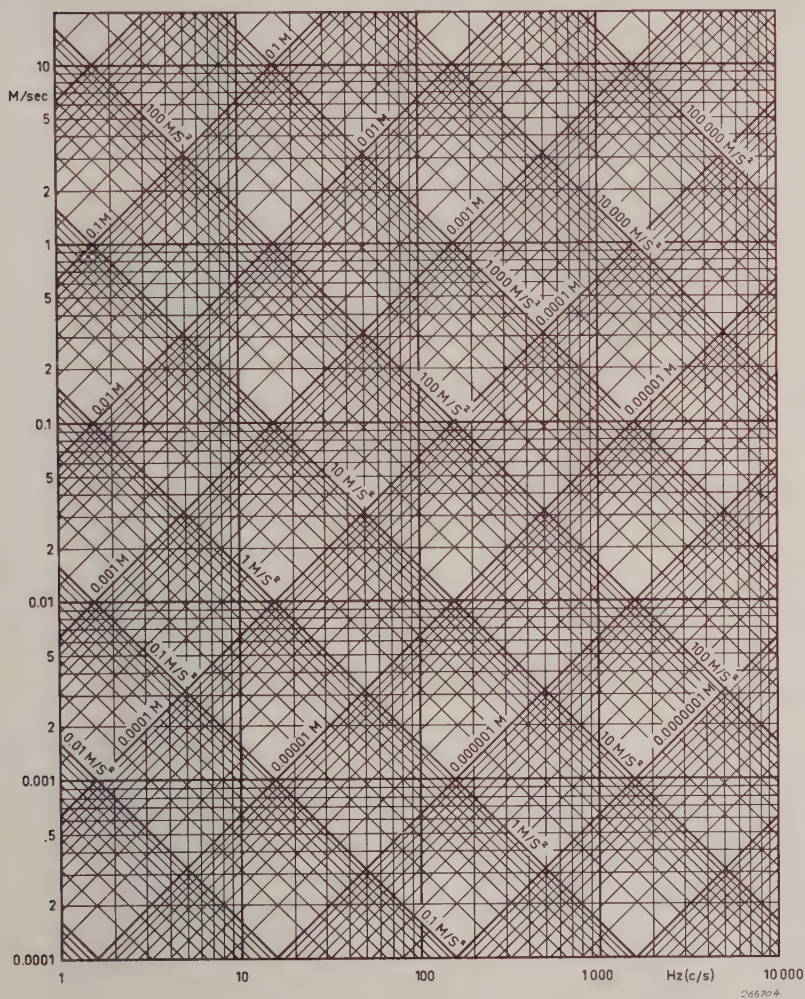
$$-31.8 = (-2) \times 20 + 8.2.$$

8.2 gives from table 2.570. The g-value is then $10^{-2} \times 2.570 = 0.02570$ g.

Table for Converting Decibels into (Voltage) Ratio.

dB	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	1.000	1.012	1.023	1.035	1.047	1.059	1.072	1.084	1.096	1.109
1	1.122	1.135	1.148	1.161	1.175	1.189	1.202	1.216	1.230	1.245
2	1.259	1.274	1.288	1.303	1.318	1.334	1.349	1.365	1.380	1.396
3	1.413	1.429	1.445	1.462	1.479	1.496	1.514	1.531	1.549	1.567
4	1.585	1.603	1.622	1.641	1.660	1.679	1.698	1.718	1.738	1.758
5	1.778	1.799	1.820	1.841	1.862	1.884	1.905	1.928	1.950	1.972
6	1.995	2.018	2.042	2.065	2.089	2.113	2.138	2.163	2.188	2.213
7	2.239	2.265	2.291	2.317	2.344	2.371	2.399	2.427	2.455	2.483
8	2.512	2.541	2.570	2.600	2.630	2.661	2.692	2.723	2.754	2.786
9	2.818	2.851	2.884	2.917	2.951	2.985	3.020	3.055	3.090	3.126
10	3.162	3.199	3.236	3.273	3.311	3.350	3.388	3.428	3.467	3.508
11	3.548	3.589	3.631	3.673	3.715	3.758	3.802	3.846	3.890	3.936
12	3.981	4.027	4.074	4.121	4.169	4.217	4.266	4.315	4.365	4.416
13	4.467	4.519	4.571	4.624	4.677	4.732	4.786	4.842	4.898	4.955
14	5.012	5.070	5.129	5.188	5.248	5.309	5.370	5.433	5.495	5.559
15	5.623	5.689	5.754	5.821	5.888	5.957	6.026	6.095	6.166	6.237
16	6.310	6.383	6.457	6.531	6.607	6.683	6.761	6.839	6.918	6.998
17	7.079	7.161	7.244	7.328	7.413	7.499	7.586	7.674	7.762	7.852
18	7.943	8.035	8.128	8.222	8.318	8.414	8.511	8.610	8.710	8.810
19	8.913	9.016	9.120	9.226	9.333	9.441	9.550	9.661	9.772	9.886

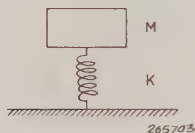
Frequency, Acceleration, Velocity, Displacement Nomograph. (RMS-values).



Temperature:

$$F = \frac{9}{5} C + 32$$

$$C = \frac{5}{9} (F - 32)$$

Single Degree of Freedom System.

M = mass (kg)

K = stiffness (Newt/m)

$$\omega_o = \sqrt{\frac{M}{K}} = 2\pi \times \text{resonance frequency}$$

$$\omega_o = \sqrt{\frac{g}{\Delta_{st}}} \text{ where } \Delta_{st} = \text{static deflection of the mass.}$$

For Single Frequency (Sinusoidal) Vibration.

Acceleration	Velocity	Displacement
$a \cos \omega t$	$\frac{1}{\omega} a \sin \omega t$	$-\frac{1}{\omega^2} a \cos \omega t$
$-\omega v \sin \omega t$	$v \cos \omega t$	$\frac{1}{\omega} v \sin \omega t$
$-\omega^2 d \cos \omega t$	$-\omega d \sin \omega t$	$d \cos \omega t$

RMS Values.

A	A/ω	A/ω^2
ωV	V	V/ω
$\omega^2 D$	ωD	D

Conversion of Length.

m	cm	mm	ft.	in
1	100	1000	3.281	39.37
0.01	1	10	0.0328	0.3937
0.001	0.1	1	0.00328	0.03937
0.3048	30.48	304.8	1	12
0.0254	2.54	25.4	0.0833	1

Conversion of Weight (Mass).

kg	gram	lbs.	oz.
1	1000	2.205	35.3
0.001	1	0.0022	0.0353
0.4536	453.6	1	16
0.02835	28.35	0.0625	1

Conversion of Acceleration.

g	m/sec ²	cm/sec ²	ft/sec ²	in/sec ²
1	9.81	981	32.2	386
0.102	1	100	3.281	39.37
0.00102	0.01	1	0.0328	0.3937
0.03109	0.3048	30.48	1	12
0.00259	0.0254	2.54	0.0833	1

10. Specifications

OSCILLATOR SECTION

Three types of output are available from the oscillator:

1. Narrow Bands of Random Noise
2. Sine-waves
3. Wide Band Random Noise.

1. Narrow Bands of Random Noise.

A narrow band of random noise can be swept automatically throughout the frequency range 10 to 10000 Hz (or 5–10000 Hz) with a constancy of power better than ± 1 dB.

- a. **Bandwidths.** Four different bandwidths can be selected. The "shape" of the noise bands are tabulated below:

Attenuation vs. Frequency Characteristics of the Noise Bands.

Frequency	B = 3 Hz	B = 10 Hz	B = 30 Hz	B = 100 Hz
$f_0 \pm B^*$	> 10 dB	> 20 dB	> 20 dB	> 20 dB
$f_0 \pm 2 B^*$	> 20 dB	> 40 dB	> 40 dB	> 50 dB
$f_0 \pm 3 B^*$	> 30 dB	> 50 dB	> 50 dB	> 60 dB

- b. **Voltage Distribution.** Symmetrical Gaussian (normal) instantaneous voltage distribution up to four times the RMS value (4σ) at full output voltage.
- c. **Output:** Maximum RMS output voltage is 10 V. Load impedance should be greater than $10 \text{ k}\Omega // 3 \text{ nF}$. Harmonic distortion is less than 0.5 %. The signal to extraneous noise ratio is better than 60 dB at maximum output.
- d. **Frequency Scales:** 10–10000 Hz truly logarithmic. Accuracy 1 % ± 0.5 Hz.
5–10000 Hz. Obtained by subtracting 5 Hz from the one above.

2. Sine-waves.

Continuously tuneable within the frequency range 10 to 10,000 Hz (or 5–10000 Hz). Amplitude accuracy better than ± 0.5 dB.

*) B = 3 dB noise bandwidth. The spectrum density within the bandwidth, B, is uniform to within ± 1.5 dB.

- a. **Output:** Maximum 10 V (RMS). Load impedance should be greater than $10\text{ k}\Omega//3\text{ nF}$. Harmonic distortion is less than 0.5 %. The signal to noise ratio is better than 60 dB at maximum output.
- b. **Frequency Scales:** 10–10000 Hz truly logarithmic. Accuracy 1 % $\pm 0.5\text{ Hz}$.
5–10000 Hz. Obtained by subtracting 5 Hz from the one above.

Constant Level Output, common to 1 and 2 above.

- a. 1 V RMS following the frequency sweep of the generator.
 - b. The voltage type corresponds to the setting of MODE SELECTOR.
 - c. The frequency characteristic is flat within $\pm 1\text{ dB}$ in the range 5–10,000 Hz.
 - d. Distortion is less than 1 %.
 - e. Load should be greater than $10\text{ k}\Omega//3\text{ nF}$.
 - f. Signal to noise ratio is better than 45 dB.
3. **Wide Band Random Noise.**
- a. **Frequency Spectrum:** Flat to within $\pm 1\text{ dB}$ in the range 5–10,000 Hz.
 - b. **Output Voltage:** 10 V RMS ($8 \times 10^{-3}\text{ V}^2/\text{Hz}$ approx.).
 - c. **Voltage Distribution:** Symmetrical Gaussian (normal) voltage distribution up to four times the RMS value (4σ) at full output voltage.
 - d. **Constant Level Output.** No useful output in Wide Random operation.

COMPRESSOR SECTION

- a. **Frequency Range:** Flat to within $\pm 0.5\text{ dB}$ from 5 to 10000 Hz.
- b. **Dynamic Range:** 80 dB selectively (40 dB is compressed to less than 1.5 dB). Required input signal for full regulation is 1 V RMS approx.
- c. **Signal Rectifier:** Average absolute type, with interchangeable integration times (regulation speeds).
- d. **Regulation Speed:** 1 – 3 – 10 – 30 – 100 – 300 – 1000 and 3000 dB/sec. Selectable by means of a switch, or automatically programmed.
- e. **Compression:** Indicating meter measures the amount of compression in the range 0–80 dB with METER SWITCH in position "Compression".

METER SECTION

- a. **Signal Rectifier:** Quasi – RMS.
- b. **Integration Times:** Six meter time constants selectable 0.3, 1, 3, 10, 30, and 100 sec. (For definition of the time constants vide "Control Knobs, Terminals etc.").
- c. **Meter Scales:** Semi-logarithmic voltage scale 0–10 V. Semi-linear dB scale 0–20 dB. Compression scale 0–80 dB. Scales are mirrored.
- d. **Indicating Meter:** Moving coil instrument fully protected against electrical overload.

MISCELLANEOUS

- a. **Automatic Frequency Scanning:** A built-in frequency sweep unit allows automatic scanning of any predetermined part of the frequency range (or full 360° rotation of the frequency scale pointer) at 136 different scanning speeds. The transistor power supply used to control the sweep motor allows synchronization between the oscillator frequency sweep and external recording devices*). Scanning speed range: 0.3 degrees/min to 335 degrees/min. Fully reversible scan.
- b. **Frequency Limit Controls:** Front-panel set screw adjustment, or partial blocking by means of built-in cam-discs.
- c. **Automatic Cross-over Control:** Automatic Cross-over at any frequency between 15 Hz and 1000 Hz. Type of cross-over can be remotely controlled from the Vibration Meter Type 2502.
- d. **Remote Control:** Start-Stop of automatic frequency scan. Forward-reverse changing of frequency scan. Stand by. 33 to 1 scanning speed change.
- e. **Stand-by:** When Generator is set to stand-by the output voltage is suppressed by more than 70 dB in relation to full output voltage.
Decay Time: 150 msec. approx. (90 % – 10 %).
Rise Time: Without compressor working: 30 msec. approx. (10 % – 90 %).
 With compressor working: Dependent on compressor speed setting.
- f. **Master-Slave Arrangement:** Special parallel operation of two or more Generators.
- g. **Warning System:** A lamp indicates with a red light that the compressor is operating.
- h. **Vibration Level Preset:** The whole vibration test system can be set up for the required vibration level without feeding any signal to the power amplifier and shaker.
- j. **Resetting Power Amplifier:** When the PA has been disconnected by a system protecting circuit, it may be reset by turning OUTPUT VOLTAGE control fully counter-clockwise.
- k. **Pilot Voltage:** 0–6 V DC governed by the angular position of the frequency scale pointer, intended for the Vibration Programmer Type 4411.

GENERAL

Overall Stability: Operates within stated tolerances for a mains voltage deviation of up to $\pm 10\%$. Operable up to $\pm 15\%$ voltage deviation.

Power Supply: 100, 115, 127, 150, 220 or 240 volts, 50–400 Hz. Power consumption: 120 W.

Dimensions:

Type 1042B. Mahogany cabinet. Width: 51 cm, height: 52 cm, depth: 34 cm.

Type 1042C. For 19" rack mounting.

*) E.g. the Brüel & Kjær Level Recorder Type 2305.

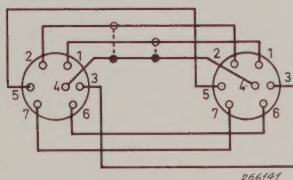
Weight: 64 lbs. (29 kg).

Accessories Included: 1 power cord, 1 telephone jack (JP 0009), 3 Cannon WK-4-21C (JP 1004), 6 Cannon WK-A7-21C (JP 0700). Various panel lamps and fuses.

Extra Accessories Available:

Standard Cable AO 0058 (length 2 m).

Standard



Connection Box JJ 0036 (for Standard Cables). 5 parallel connected 7-pin sockets in metal casing.

